

[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

The
AMERICAN JOURNAL
OF ROENTGENOLOGY
AND RADIUM THERAPY

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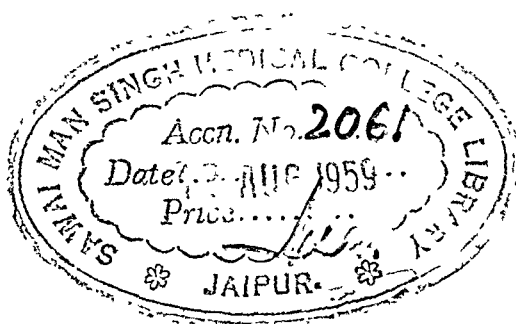
VOLUME 59

JANUARY TO JUNE, 1948



CHARLES C THOMAS : SPRINGFIELD, ILLINOIS
1948

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 59

JANUARY, 1948

No. 1

THE TIME FACTOR IN RADIATION THERAPY*

By CHARLES L. MARTIN, M.D.

DALLAS, TEXAS

A PRESIDENTIAL address provides one with an unusual opportunity to speak his mind freely without fear of contradiction and I hope you will bear with me while I take full advantage of this prerogative. If I seem a little vindictive please remember that I grew up as the son of a pioneer radiologist possessed of an unshakeable conviction that radiation therapy would become one of our most valuable weapons in the war against cancer. It has also been my good fortune to know some of the older radiation therapists and to be inspired by their achievements and visions for the future. This explains in some degree my deep feeling of disappointment over what impresses me as a growing lack of interest among the younger men in the intriguing field of therapy.

Although our specialty has been in existence for less than fifty years, too many of us take the attitude that the field of radiation therapy has reached its peak, leaving no new problems to be investigated. Certainly research in other directions must be carried on vigorously but the unsolved questions which still confront the physician using roentgen rays and radium in the treatment of neoplastic diseases should constitute a

direct challenge to the young man with an inquiring mind.

He should, for instance, be surprised when he learns that the voluminous material produced for us by the physicists has failed to provide a practical biological unit of measurement. The development of the roentgen was an outstanding achievement, but by no stretch of the imagination can it be looked upon as a satisfactory measure of biological effect unless in each instance it is qualified by the tabulation of the variable factors controlling its production. Although this fact has been known for years, total depth doses estimated by adding gamma roentgens and x-ray roentgens still appear in the literature. We are indeed sorely in need of a unit which represents a carcinomacidal dose for a given type of cancer regardless of the kind of radiation which may be used to produce it.

For years the threshold erythema dose was used as a unit of measurement and even though it is now looked upon with great disfavor it is still the only biological unit which has received intensive study. It lost prestige when normal skin and malignant tissue were found to recover at different rates from a given total dose of radiation

* President's Address delivered at the Twenty-ninth Annual Meeting, American Radium Society, Atlantic City, N. J., June 9-10, 1947.

administered over a prolonged period of time. As a result, the time factor became one of the most important variables in radiation therapy and we still have much to learn about its proper utilization.

Radiologists frequently state that the carcinomacidal tissue dose for squamous cell carcinoma is 7,000 gamma roentgens and the physicists have indicated that this

plotted from data published by Quimby and MacComb^{1,2} some ten years ago. This curve shows the increasing doses in milligram-hours needed to produce a threshold erythema dose with treatment periods varying from three hours up to ninety-six hours. I have adopted a time interval for radium needle therapy of 168 hours and the curve has been extended to this point in an

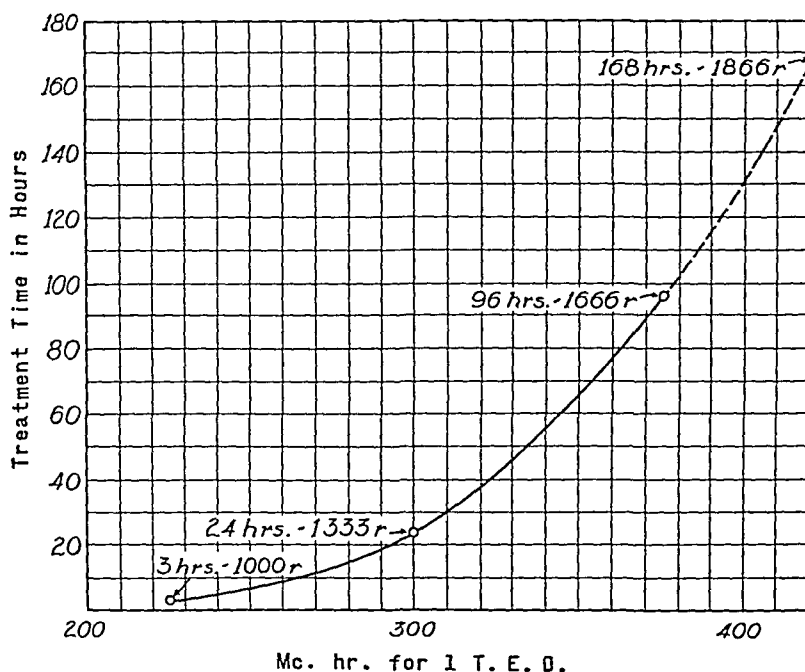


FIG. 1. Curve plotted from data of MacComb and Quimby showing how the number of gamma roentgens needed to produce a threshold erythema dose increases as the time factor is increased.

amount of radiation should produce 7 threshold erythema doses. However, this statement is true only when the entire treatment is given within a period of a few hours, a condition which is rarely if ever met with in practice.

It apparently is not generally appreciated that the biological effect produced by a given number of roentgens steadily decreases as the time factor is prolonged and consequently no dose indicated in roentgens is of value unless the time of administration is given. The problem of total dosage estimation becomes even more complex when several series of treatments are given with recovery periods between them.

The importance of the time relationship may be illustrated by a curve (Fig. 1)

effort to determine a theoretical value for this treatment time. Since a threshold erythema dose produced by gamma rays in three hours is produced by 1,000 gamma roentgens all of the values on the curve may be estimated in gamma roentgens and it becomes evident that with a given applicator the number of gamma roentgens needed to produce a threshold erythema dose must be increased from 1,000 to 1,866 T.E.D. when the treatment time is increased from three hours to 168 hours.

From clinical experience I have become convinced that a tissue dose of 6,000 gamma roentgens delivered with low intensity radium needles in a period of 168 hours will, as suggested by Paterson and Parker,³ completely destroy most primary squamous

cell carcinomas growing in the human body. From the data presented in Figure 1, a curve has been plotted (Fig. 2) representing the threshold erythema values produced by 6,000 gamma roentgens for treatment periods varying from three hours to 168 hours. If it be assumed that 6,000 gamma roentgens produce 6 T.E.D. in three hours,

by Quimby and MacComb. At any rate, it seems fair to designate the amount of gamma radiation capable of producing 3.2 T.E.D. as a carcinomacidal dose when this figure is calculated with proper consideration of the time factor.

This leads one to wonder whether the quantities of other types of radiation ca-

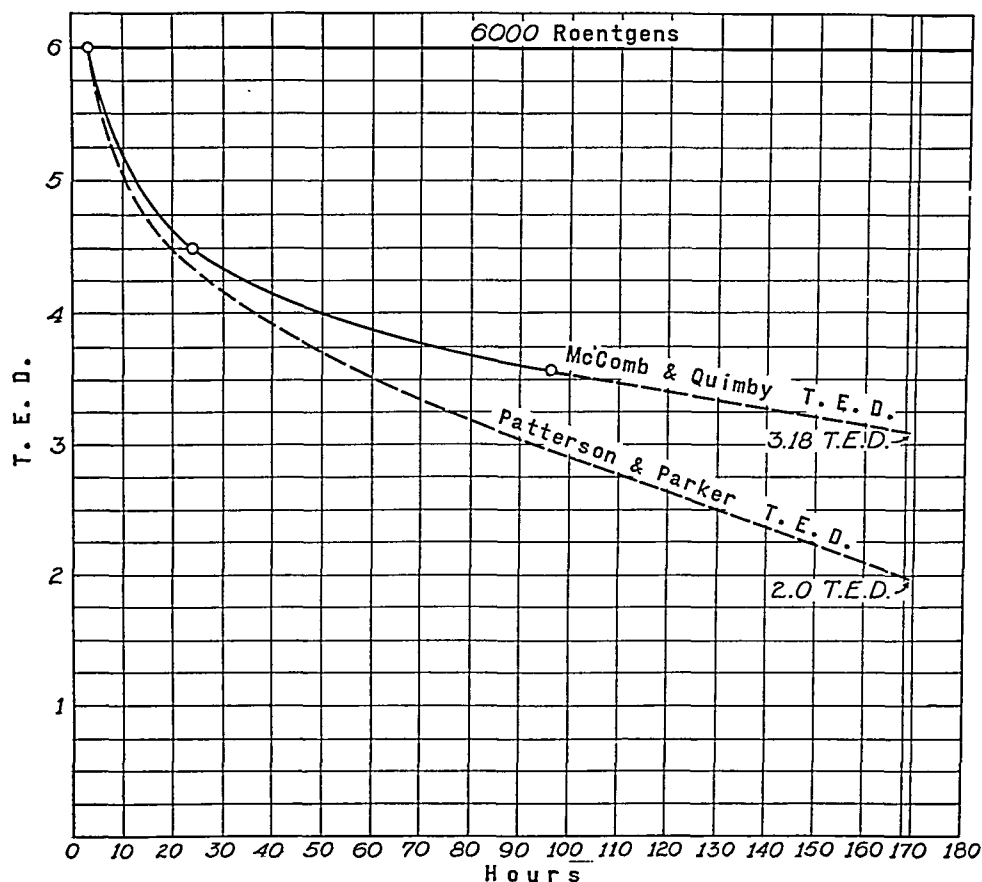


FIG. 2. The upper curve shows how the number of threshold erythema doses delivered by 6,000 gamma roentgens decreases as the time factor is increased. The carcinomacidal dose at the end of 168 hours amounts to approximately 3.2 T.E.D. The lower curve is plotted on the assumption of Paterson and Parker that 6,000 gamma roentgens delivers 2.0 T.E.D. in 168 hours.

a value of 3.2 T.E.D. is obtained for 168 hours. Paterson and Parker claim that 3,000 r produces a faint erythema under these conditions and if this reaction can be considered to correspond to a threshold erythema dose their observations suggest that 6,000 r should produce 2 T.E.D. However, it seems reasonable to suppose that the faint erythema described by the British authors may be somewhat more intensive than the threshold erythema dose described

pable of producing approximately 3.2 T.E.D. with proper corrections for the time factor might not also be carcinomacidal. In our own clinic an effective technique has been developed for treating large squamous cell carcinomas of the face with 200 kv. roentgen rays. The lesion shown in Figure 3 measured 8.0 cm. in diameter and 2.0 cm. in thickness. A daily dose of 315 roentgens, measured in air, was given through a 10.0 cm. portal with a filter of 0.5 mm. of copper

and 1.0 mm. of aluminum and a target-skin distance of 50.0 cm. for a period of twelve days with an excellent result. By using the curves published by Quimby and MacComb the effect of the time factor can be estimated and it is found that although the

are made with due regard for the time factor. Perhaps the threshold erythema dose may again become a useful unit if it is properly calculated. I hope that others will check their proved techniques in an effort to determine whether or not an effec-



FIG. 3. Five year cure of large squamous cell carcinoma of the face obtained with a divided dose roentgen-ray technique delivered in 312 hours. The dose delivered to the base of the tumor when corrected for the time factor amounts to 3.2 T.E.D.

total dose administered was 3,780 r the effective dose delivered to the surface on the twelfth day was 1,778 r. The dose with backscatter amounted to $1.36 \times 1,778$, or 2,418 r. The dose 2.0 cm. below the surface amounted to approximately 90 per cent of this value, or 2,176 r. When this figure is divided by 680, which represents the number of roentgens generated at 200 kv. required to produce 1.0 T.E.D., the resulting figure curiously enough is 3.2.

This result seems to suggest that even when two different types of radiation are used the carcinomacidal dose produces the same effect on the skin if the calculations

tive dose of approximately 3.2 T.E.D. is carcinomacidal for squamous cell carcinoma with all types of radiation.

Even though this figure may not prove correct a study of the foregoing data should make it quite apparent that equal quantities of roentgens delivered at different time intervals have different biological effects and that it is quite incorrect to estimate total doses by adding them together.

In an effort to establish 6,000 gamma roentgens as a carcinomacidal dose for all cases treated, a constant time factor of 168 hours has been adopted for low intensity radium needle implantations done in our

clinic. Under such conditions the needle pattern becomes the only important variable. Paterson and Parker recommend patterns designed to deliver a uniform dose of roentgens delivered in 168 hours without the formation of permanent necroses, it occurred to us that it might be worth while to develop simplified patterns which de-

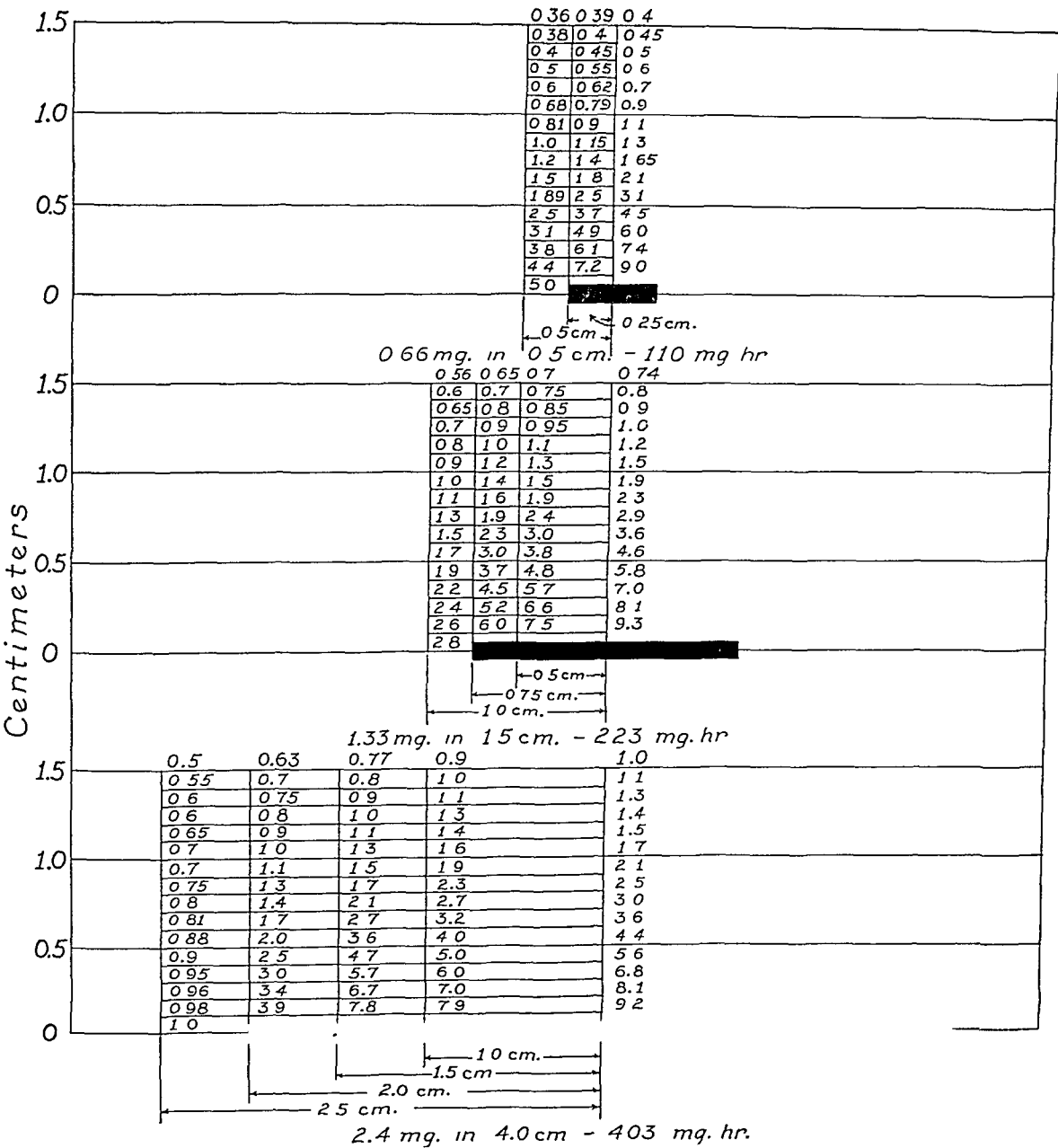


FIG. 4. Doses delivered at various points about the active lengths of three low intensity radium needles in 168 hours. The figures are converted into gamma roentgens when multiplied by 1,000.

6,000 roentgens to all of the malignant cells in an implanted tumor but in our experience this ideal procedure has often proved most difficult and sometimes practically impossible. Since the mucosa of the mouth will tolerate a dose of 12,000 gamma

liver doses ranging from 6,000 r to 12,000 r to all of the tumor tissue and which may be used rapidly without the necessity of resorting to preliminary calculations. Tumors of almost any shape may be successfully treated with combinations of

three standard needles. They have active lengths of 0.5, 2.0 and 4.0 cm. and contain 0.66, 1.33 and 2.4 mg. of radium respectively. The filtration amounts to 0.5 mm. of platinum. Since the time factor is constant it is possible with the aid of the tables published by Quimby⁴ to produce

gens delivered by the needles situated within a radius of 1.5 cm. of the point in question.

Many carcinomas located on the face and lip and in the mouth either grow as flat masses or may be reduced to such layers of tissue by the use of electrosurgery.

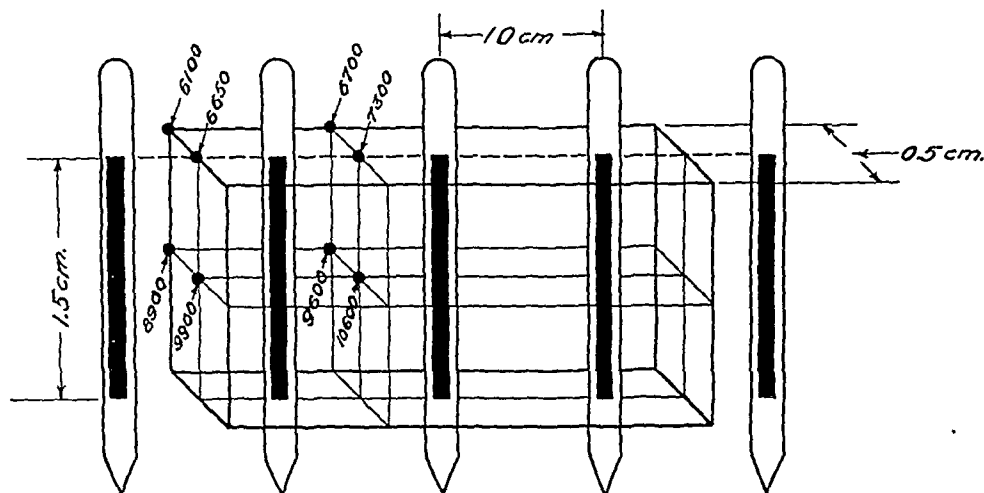


FIG. 5. Dosage in gamma roentgens delivered to various points in a piece of tissue measuring $0.5 \times 1.5 \times 3.0$ cm. in 168 hours by five 1.33 mg. radium needles placed parallel to one another. All doses are within safe limits for normal tissue (12,000 r) and none is less than 6,000 r, the carcinomacidal dose.

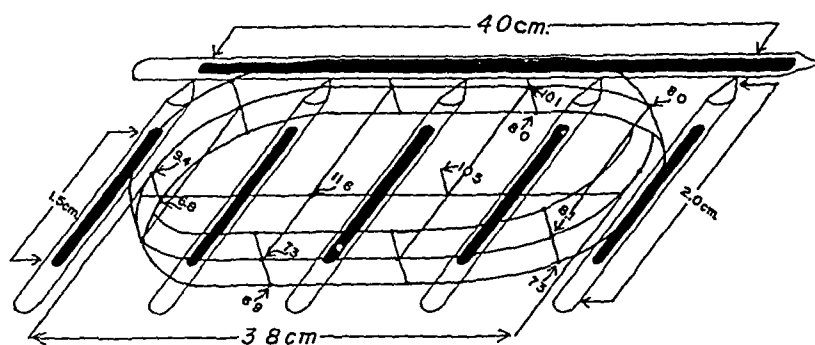


FIG. 6. Radium needle pattern designed to deliver doses ranging from 6,900 r to 11,600 r to all portions of an oval piece of tissue measuring $0.5 \times 2.0 \times 3.8$ cm. in 168 hours. The point doses are converted to gamma roentgens by multiplying the figures on the chart by 1,000.

the simple dosage chart shown in Figure 4. The figures on the chart when multiplied by 1,000 represent the number of gamma roentgens delivered at various points about the active lengths of each needle. To estimate the dose delivered at any point in a given tumor it is only necessary to draw the implantation pattern used to scale and add together the total roent-

The use of low intensity needles in such layers was described in a previous article.⁵ The doses produced in a slab of tissue measuring $1.5 \times 3.0 \times 0.5$ cm. is illustrated in Figure 5, and it is interesting to note that they vary from 6,100 to 11,600 roentgens when the needles are spaced 1.0 cm. apart. Since all of the doses are carcinomacidal for squamous cell cancer and are within safe

limits for normal tissue recovery, the implantation should be effective and this has proved true in practice. The length of the implanted layer may be extended indefinitely without changing the dosage range and with larger tumors longer needles may be used or some of them may be placed at right angles to others so as to maintain

apart in the rows, dosages delivered within the tumor are shown to vary from 6,000 to 11,300 roentgens.

These few examples show that it is possible by using a constant time factor to designate effective carcinomacidal doses in terms of gamma roentgens.

Since it was shown in the first portion

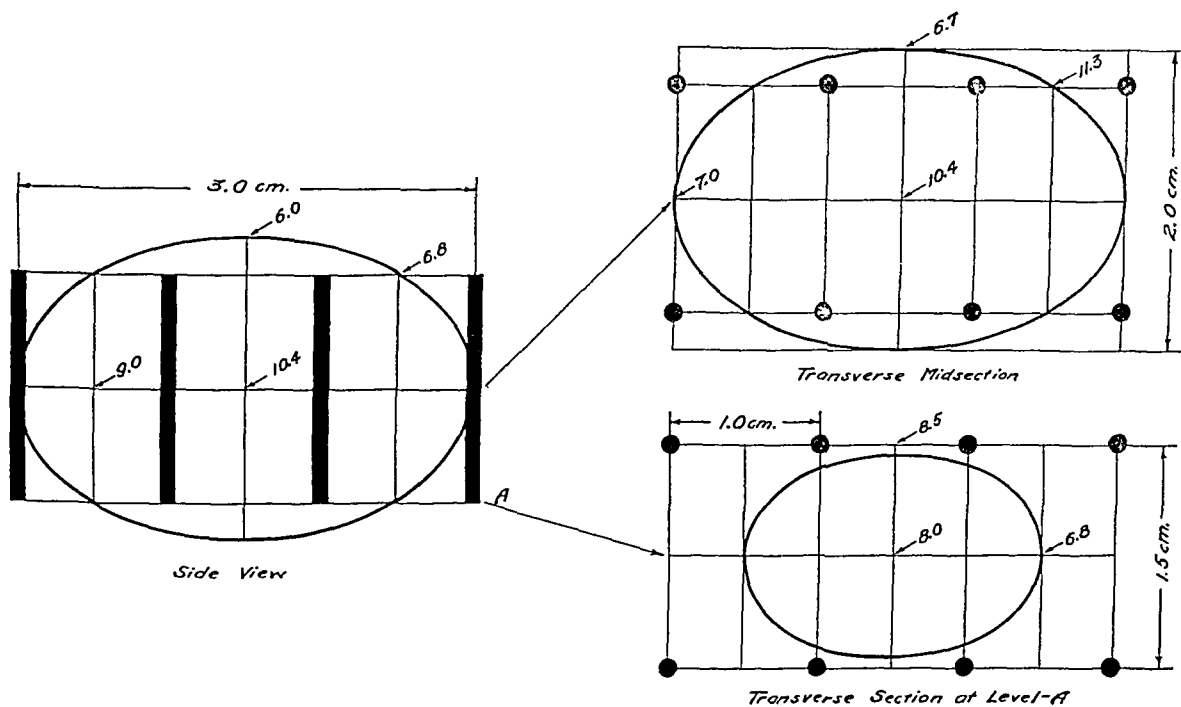


FIG. 7. Radium needle pattern for an oval solid tumor measuring 2.0×3.0 cm. delivering doses ranging from 11,300 r to 6,000 r to all points in the mass in 168 hours. Two rows of 1.33 mg. needles are spaced 1.5 cm. apart.

the same dosage limits. Such an arrangement is shown in Figure 6. In this instance these limits vary from 6,800 to 11,600 roentgens in a layer measuring $3.8 \times 2.0 \times 0.5$ cm. Once the operator familiarizes himself with the various patterns which may be used effectively he no longer needs to bother with preliminary calculations before implanting layers of varying sizes and shapes.

In a similar manner workable patterns for solid tumors may be estimated. A suitable implantation for an egg-shaped tumor measuring 3.0×2.0 cm. is illustrated in Figure 7. By using two rows of 1.33 mg. needles with the rows spaced 1.5 cm. apart and the needles spaced 1.0 cm.

of this paper that the carcinomacidal doses of various types of radiation may be those capable of producing the same number of threshold erythema doses, one is strongly tempted to estimate combined doses of gamma rays and 200 kv. roentgen rays by adding together the effective threshold erythema dose produced by each type of radiation. In 1930 Quimby and Pack⁶ published some observations which indicate that such a procedure is not proper. They found that for combinations of gamma rays and hard roentgen rays in equal parts it required one-third more radiation to produce a threshold erythema than for either of these types used alone. It is obvious, then, that the sum obtained by

adding together the threshold erythema doses produced by a given quantity of gamma rays and a given quantity of roentgen rays given to different areas does not represent the change produced on the skin when these quantities are administered to the same area.

It has been our custom during the past ten years to use such a technique in treating metastatic cervical lymph nodes. The nodes in a given area are implanted with low intensity radium needles using the layer technique so that the minimum effective dose amounts to 6,000 gamma roentgens given in a period of 168 hours. While the needles are in place a dose of 350 r, measured in air, is administered daily to the same area using 200 kv. roentgen-ray equipment until a total of 2,100 r has been administered in a period of 144 hours. The minimum threshold erythema dose given with radium amounts to 3.2 and that calculated for the roentgen-ray dosage at a depth of 2.0 cm. below the surface is 2.0 T.E.D. However, we know that the effect on skin is less than the sum of these two figures and for that reason the massive dosage can be safely given. The real problem is the determination of the effect produced on the cancer cells in the lymph nodes and at present I know of no way in which this effect may be accurately estimated. It is

evident, then, that our methods of mensuration are crude and inaccurate and badly in need of revision and improvement.

In conclusion, may I say that radiation therapy is still a rich field for investigation and study and that its promising ramifications should be more thoroughly and intensively studied before we revert entirely to radical surgery or place our trust in magic new chemicals which have as yet little to recommend them.

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REFERENCES

1. MACCOMB, W. S., and QUIMBY, E. H. The rate of recovery of human skin from the effects of hard or soft roentgen rays or gamma rays. *Radiology*, 1936, 27, 196-207.
2. QUIMBY, E. H., and MACCOMB, W. S. Further studies on the rate of recovery of human skin from the effects of roentgen- or gamma-ray irradiation. *Radiology*, 1937, 29, 305-312.
3. PATERSON, R., and PARKER, H. M. A dosage system for gamma ray therapy. *Brit. J. Radiol.*, 1934, 7, 592-632.
4. QUIMBY, E. H. Dosage table for linear radium sources. *Radiology*, 1944, 43, 572-577.
5. MARTIN, C. L. The layer technique in radium needle therapy. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 48, 377-383.
6. QUIMBY, E. H., and PACK, G. T. Further studies on the skin erythema with combinations of two types of radiation. *Radiology*, 1930, 15, 30-41.



PHYSIOBIOLOGY AND GENERAL MANAGEMENT OF CHRONIC ULCERATION OCCURRING AFTER IRRADIATION*

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A REVIEW of the factors which contribute to the necrosis and repair of tissue will aid in evaluating faulty healing after radiotherapy and in directing the management of radiodermatitis according to physiological concepts. Radiodermatitis was first reported by Marcuse²³ in 1896. The histopathological changes associated with radiodermatitis and post-irradiation necrosis have been well summarized by Wolbach,⁴⁰ Ewing,¹⁴ and Warren.³⁸ Irradiation modifies tissues, not only through direct injury to cells,⁶ but also by reduction of blood supply,²⁷ and replacement of original cells by hyalinized connective tissue.

The physiological disorders and injurious agents which promote cellular necrosis may be grouped as follows: (1) constitutional disease, (2) devascularization, (3) infection, (4) devitalization and sequestration, (5) trauma, (6) inadequate regeneration, and (7) residual neoplasm. Cellular death results primarily from anoxia and direct injury. Constitutional disorders lower the threshold of susceptibility and impair healing. Necrosis is extended primarily by infection of devitalized tissue. Deficient regeneration results primarily from impaired circulation, interposed sequestering or neoplastic tissue, and to some extent from depressed mitosis resulting from senility and cytological derangement.⁶

CONSTITUTIONAL DISEASE

Constitutional disease impairs the nutrition of tissues and lowers resistance to infection.^{2,7} Malnutrition, uncontrolled diabetes, thyroid disease, nephritis, senility, cardiovascular disease, syphilis, chronic infectious processes, and anemia depress

vitality and interfere with wound repair. These systemic disorders should be corrected, if possible, in the patient receiving intensive radiotherapy. Hypoproteinemia and deficiency of vitamin C retard healing and should be corrected by adequate diet or food supplements.²⁸ The incidence of hypoproteinemia among cancer patients is estimated at 30 to 50 per cent,¹⁰ being most reduced in cancer of mouth, throat and gastrointestinal tract. Anemia aggravates anoxia in tissues already suffering from impaired circulation, and tissue repair is promoted in such regions by elevation of hemoglobin to normal levels through transfusion and appropriate medical therapy.

DEVASCULARIZATION

Circulatory deficiency increases the probability of post-irradiation necrosis. The deficiency may be constitutional, as in the case of arteriosclerosis, syphilis or anemia; regional, as in the case of ligation of arterial trunks; or local, as from contracting scar tissue, thromboses, edema and endarteritis. In case the oxygen delivered to tissues by the circulating blood falls below critical requirements, necrosis will occur and repair will be impossible. Reduction of vascularity by ligation of regional vessels or endarteritic changes from previous radiotherapy increases the incidence of post-irradiation necrosis. The small vessels are most susceptible to injury and occlusion by irradiation, and the incidence of post-irradiation necrosis is definitely higher in regions where the blood supply is limited to small vessels, as in the case of a shallow layer of soft tissue stretched over bone as on the back of the hand, across the temporofrontal

* Preliminary review presented at the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America, Chicago, Ill., Sept. 24-29, 1944.

area, and over the bridge of the nose. Such regions lack penetrating vessels through their base, and vascularity is dependent entirely upon a network of small vessels entering through the peripheral margin.

The vascular changes produced by irradiation are injury to endothelium of vessels leading at first to hyperemia with exudation and edema and subsequent thromboses of some smaller vessels. The later changes are occlusive endarteritis and vascular constriction by connective tissue proliferation.²⁷ Vascularity of irradiated tissues is to be preserved as far as possible by the avoidance of unnecessary surgery and reduction of infection. Daland⁹ emphasizes that post-irradiation necrosis may be precipitated by ligation of large vessels supplying a previously irradiated area. In the timing of radiotherapy it is desirable to complete the full course of irradiation before the blood supply becomes reduced by occlusive changes from the initial treatment. Any previously administered course of irradiation greatly increases the hazard of necrosis following subsequent radiotherapy given over the same area. It is therefore particularly desirable that the first course of radiotherapy shall be adequate for the eradication of carcinoma.

It would be desirable to increase the circulation of blood through areas of post-irradiation necrosis, but relatively little can be done to effectively dilate endarteritic vessels. Leriche and Fontaine²⁰ have advocated peri-arteriolar sympathectomy and report healing in 12 of 27 cases so treated by themselves and other surgeons. Erythema during the initial phases of radio-dermatitis accelerates its onset and aggravates its severity. Agents productive of erythema can be employed only during the subsiding and chronic phase of radio-dermatitis. Although ultraviolet blistering will at times precipitate ulceration in atrophic irradiated skin it has been advocated by Eidinow¹² and others in the treatment of post-irradiation necrosis. Infrared and local heat produce erythema and promote vasodilatation to some extent, but the

elevated temperature has the undesirable effect of increasing the metabolic requirements of tissue, thereby aggravating rather than benefiting the anoxia. Cold packs, therefore, are usually more beneficial than hot packs in the treatment of radiodermatitis and post-irradiation necrosis. Estrin ointment has been credited by Moseley²⁵ with benefiting radionecrosis by production of erythema. Removal of the periphery of a post-irradiation ulcer by cautery or excision may provide a more adequate blood supply through elimination of the occluded terminal vessels from about its periphery. Furthermore, regeneration then may be possible from the newly exposed vessels, whereas the old terminal vessels were so damaged as to be incapable of regeneration.

INFECTION

Infection is the most destructive influence in the progressive necrosis of devitalized tissue following irradiation. Bacteria invade the devitalized cells and thrive in the necrotic debris. Persisting infection aggravates circulatory deficiencies through thrombosis, edema and scar tissue formation. Severe pain also results from the exposure and compression of nerve endings. Infection may be residual from an infarcted septic neoplasm or enter the subcutaneous tissues by way of prolonged exposure through persistent ulceration. Delayed healing is to be anticipated with lesions over 5 cm. in diameter, in areas of poor vascularity, in regions exposed to excess moisture and contamination as about the perineum, and in the case of lesions involving bone or cartilage. Previously well healed irradiated areas frequently develop necrosis following the entrance of infection through a small break in the skin or mucous membrane. Infection of subcutaneous tissues is to be prevented primarily through prompt healing within six to ten weeks after irradiation and continued intactness of the skin beyond that time.

Established infection occurring within a necrotizing carcinoma or in devitalized tissue may be benefited by the application

of bacteriostatic or antibiotic drugs.^{26,31,32} Sulfanilamide is the most soluble of the sulfonamides, but it is not effective against staphylococci nor anaerobic streptococci. Sulfathiazole is relatively insoluble, but is much more effective against staphylococci. Micraform sulfathiazole is effective when applied as a sterile powder, in an emulsion, or as a 5 to 10 per cent ointment in a water soluble base. The bacteriostatic effect of sulfonamides is inhibited by pus or necrotic tissue. The sulfanomides are relatively inexpensive and their action is prolonged. Allergic susceptibility to sulfonamides may develop a vesicular rash with aggravation of the radiodermatitis.

Penicillin is effective against the anaerobic streptococci as well as against the staphylococci and other organisms affected by the sulfonamides. Furthermore, penicillin is effective in the presence of necrotic tissue. Since its effectiveness persists for only a few hours, it must be repeatedly replenished every two hours. It is best applied as a wet dressing of 200 units of penicillin per cubic centimeter of normal saline. Streptomycin is preferable to sulfonamides and penicillin only when infection is due to the gram negative bacilli. Tyrothricin, like penicillin, is effective against gram positive bacteria, including staphylococci and anaerobic streptococci. It is more persistently effective than penicillin, but is inactivated by saline. It is useful as a topical application 0.5 to 1 mg. per cubic centimeter of distilled water. It is also available in a hydrophilic ointment, tyroderm (Sharp and Dohme). Tyrothricin is without effect by mouth and is dangerous when given intramuscularly or intravenously. In general, tyrothricin provides a very satisfactory antibiotic wet dressing except when the infection is due to gram negative bacilli.

The shorter ultraviolet range is superficially bactericidal, but lacking in penetration. The application of alcohol and other cytotoxic antiseptics is contraindicated, since it causes further injury to tissues and inhibits regeneration.

DEVITALIZATION AND SEQUESTRATION

Devitalized tissues usually survive or persist without troublesome complications as long as infection is excluded by an intact skin or mucous membrane. Bone and cartilage in particular, and fascia to some extent, are subject to devitalization and delayed sequestration. After intensive irradiation the osteoblasts and osteocytes disappear, leaving empty lacunar spaces in bone.³⁸ Final necrosis and sequestration result from secondary infection to which the irradiated bone, cartilage and fascia are more susceptible due to their poor vascularization and devitalized state. Devitalized tissue interferes with repair through acting as a foreign body interposed between regenerating vital cells, thereby thwarting the vascularization and bridging of viable tissue. Devitalized tissue invites infection, serving as a culture medium and repository for bacteria.

The management of devitalized tissue consists of first, the prevention of sequestration by exclusion of infection, and later, the elimination of necrotic tissue when sequestration has occurred. An intact skin or mucous membrane is the only real protection for these devitalized tissues against infection. Post-irradiation osteomyelitis and sequestration of the mandible can be avoided frequently by the extraction of all teeth from the area irradiated prior to or during the administration of radium therapy. Osteomyelitis of the jaw is notoriously frequent when teeth are extracted three months to six years following intensive irradiation. Since bone or cartilage invaded by cancer from the skin or mucous membrane commonly develops infection following eradication of the cancer by radiotherapy, surgical resection warrants consideration in the treatment of such cases.

Tissues which have been fully devitalized by the progress of infection partially separate, and the elimination of this sequestering tissue becomes a problem. In the case of the jaw bone, it is customary to await the slow development of spontaneous cleavage and loosening of the devitalized fragments. The interval for sequestration of bone can

be shortened by electrocoagulation of the devitalized area.⁴ Bone fully devitalized by heat will sequestrate after three to six months, whereas six months to three years may be required for the spontaneous elimination of bone devitalized by irradiation and infection. An osteomyelitic portion of a rib or costal cartilage may be excised. Chondritis involving the auricle of the ear or ala nasi is most expeditiously managed by excision of the diseased cartilage for prompt healing and relief of pain. Amputation may be indicated at times for osteomyelitis with or without residual neoplasm persisting after intensive irradiation of an extremity for sarcoma. Chemical debridement by one of the various oxidizing or lytic agents is of some value in the removal of necrotic soft tissue. Shreds of fascia and hyalinized soft tissues can usually be excised without anesthesia. Activated zinc peroxide oxidizes and eliminates necrotic soft tissues when applied according to the technique of Sunderland and Binkley.³⁴ Oxidation by nascent chlorine may be effected with 2.5 per cent sodium hypochlorite as advocated by Windeyer.³⁹ Azochloramide provides a more convenient and less irritating medium for dakinization. The surrounding skin must be carefully protected to avoid irritation with the continued use of zinc peroxide or Dakin's solution. Brown, McClintock and Neary³ advocate a sterile powder composed of three parts of urea to one part sulfonilamide. Urea must be discontinued as soon as the necrotic tissue has been resolved since it inhibits regeneration of tissues. Allantoin, 2 per cent, with sulfonilamide, 10 per cent, in a hydrophilic base is advocated by Finzi¹⁶ and by others.^{19,33} They claim elimination of loose necrotic tissue with no interference with regeneration. Schweitzer³⁰ advocates digestion of the necrotic tissue by pancreatic hormone.

In summary, azochloramide, allantoin or urea appears useful in the elimination of superficial necrotic tissue. Activated zinc peroxide is more effective, but requires more care in its application.

TRAUMA

Trauma promotes necrosis primarily through the introduction of infection and to a smaller extent through direct cellular injury, devitalization of tissue, and reduction of circulation. Low-Beer and Stone²¹ found delayed or recurrent post-irradiation necrosis to have been precipitated by minor trauma in nearly all cases. We use the term "trauma" in its broadest sense to include all injurious agents, whether actinic, thermal, chemical or mechanical. Healed, previously irradiated areas may break down and ulcerate following injury by sunburn, freezing, abrasions, jagged teeth, dental extraction, caustic drugs or surgical procedures. Sharp, jagged or protruding teeth are to be smoothed off or extracted. Blistering sunburn is avoided by a proper hat and protective ointment. Exposed areas should be shielded against frigid weather. The hands of outdoor workers should be protected against abrasions and weather by gloves. The avoidance of unnecessary trauma is a primary essential in the management of irradiated skin.⁵

INADEQUATE REGENERATION

The regenerative capacity of tissue is affected by the general health of the patient, regional and local circulation, presence or absence of infection, interposition of sequestering or neoplastic tissues, and the cytolytic effect of trauma as already discussed. In addition, age, irradiation, and other factors produce cytological derangement unfavorable to mitotic division and orderly growth.⁶ Intensively irradiated skin has diminished capacity for regeneration as indicated by degeneration of the basal membrane, loss of rete pegs, atrophy of the epidermis, and hyalinization of the corium.³⁸ An extensive epithelial defect such as occurs after the eradication of a large cancer, 5 cm. or more across, would tax the regenerative capacity of even normal epithelium, and may exhaust the regenerative capacity of irradiated tissue. The growth of epithelium across the ulcer

bed residual from an extensive cancer is further interfered with by associated infection, edema, devascularization and scar tissue. These combined factors definitely increase the incidence of persisting necrosis following the destruction of large cancers by irradiation. We advocate surgical closure of large defects which threaten to exhaust the regenerative capacity of the skin for prevention of infection, preservation of the underlying tissues, and provision of more durable skin as a barrier against trauma.

RESIDUAL NEOPLASM

Residual or recurrent cancer will cause persistent ulceration which may be mistaken for simple post-irradiation necrosis until its true nature is revealed by biopsy. Residual cancer acts as a barrier preventing closure of the area by epithelium. Furthermore, the area of ulceration gradually enlarges with the infiltrative extension of the disease and infarctive necrosis within the neoplasm. Cancer residual in an irradiated area presents a far more difficult problem than uncomplicated post-irradiation necrosis. The cancer must be eradicated before consideration can be given to closure of the defect. Further radiotherapy will probably be followed by persistent ulceration due to the already impaired circulation. The residual carcinoma is better eliminated by electrosurgery,²⁴ or resection rather than by further irradiation in most cases, preparatory to surgical closure.

RADIOBIOLOGY OF CELLULAR NECROSIS AND TISSUE REPAIR

The extent of biological changes produced in tissue by irradiation is graduated according to radiosensitivity of cells and governed by the cumulative absorption of radiant energy.⁶ Tissues receiving the smallest effective dosage suffer minor reparable injuries. Larger doses cause inhibition of function and depression of mitosis. Still larger dosage produces chromatin derangement, vacuolation of cytoplasm, and dissolution of cell wall, ending ultimately in cellular disintegration and death. In general,

neoplastic tissue is somewhat more vulnerable to irradiation than normal tissue due to the higher metabolic requirements and less effective repair of neoplastic tissue.

The therapist endeavors to apply radiation so as to destroy cancer with the minimal exposure of normal tissues and to so time and modify irradiation as to promote recovery of the normal tissues. Exposure of normal tissue is minimized by surface shielding and by regulation of depth dosage. The relative depth dosage is adjusted according to the extent of infiltration by the tumor through variations in wavelength, adjustments of distance, and allowances for scattering according to the wavelength and size of the area. Cancer can be effectively destroyed with radiation according to a variety of time schedules, such as a massive single dose, an attenuated single dose, a concentrated fractionated course, or by a protracted fractionated course of therapy.¹³ Recovery of normal tissues is influenced differently by these various time relations of therapy.¹ The repair of healthy tissues seems favored by fractionated treatment delivered within a period of a few days or a few weeks and by a relatively low intensity of administration. A single massive dose of high intensity usually results in prompt initial healing, but progressive scarring and atrophy do become more evident after a few years. We have seen post-irradiation breakdown of the skin with minor trauma more commonly following single massive dose therapy than after treatment of attenuated intensity, as in the case of radium or after fractionated therapy in the case of roentgen rays. On the other hand, unduly protracted fractionated therapy given over a period of months has the disadvantage of effecting an undesirable decrease in vascularity from the initial therapy by the time the final radiodermatitis appears, with consequent impairment of healing and increased susceptibility to infection and necrosis.²⁹ A subsequent course of irradiation always incurs a definitely higher hazard of post-irradiation necrosis than does the primary course. Cooper and

Robertson⁸ found that 60 per cent of their cases of post-irradiation ulceration had more than one course of treatment. They noted a high incidence of ulceration following contact therapy, probably related to repeated treatments given for persisting subcutaneous neoplasm and possibly to the high intensity of administration.

It is difficult to ascertain to what extent, if any, shorter wavelengths favor the recovery of healthy tissues as compared with longer wavelengths when delivered in dosages having equivalent cancericidal effect. The limited advantage of ultra-high voltage roentgen therapy most probably results from the lower intensity of administration and the relatively greater depth dosage rather than from any differential specificity of wavelength. Radium therapy is applied in relatively low intensity and with less irradiation of underlying tumor bed.

EXPERIMENTAL OBSERVATIONS ON MANAGEMENT OF ACUTE RADIO- DERMATITIS

The following animal experiments were conducted by us to test the effect of various applications on the onset and severity of radiodermatitis. A single dose of 2,850 roentgens in air, 80 kv. (peak), no filter, was applied through a 2 by 2 cm. portal to the dorsum of both ears of 10 rabbits. The left ear was used as a control, no applications being made to it. The agent or medication being tested was applied to the right ear daily for two months. The materials applied were tap water, mineral oil, aquaphor, 10 per cent boric acid ointment in petrolatum, 5 per cent sulfathiazole in water soluble base, zephiran chloride 1:5000, calamine lotion with 1 per cent phenol, sulfanilamide powder, and Johnson's baby powder. The period required for epilation varied from five to twenty-four days, but appeared simultaneously on the control and treated ear of each rabbit. The interval for appearance of erythema on the untreated ears varied from thirteen to thirty days, averaging twenty-two days as compared with an

average of eighteen and one-half days for the treated ears. Erythema appeared on the treated ears in the following order: aquaphor in five days; sulfathiazole ointment, eight days; mineral oil, ten days; calamine lotion with phenol, fourteen days; and boric acid ointment, seventeen days. In no case did erythema appear first on the untreated ear, and the reaction was usually most severe on the treated ear. Reactions were not accelerated or aggravated by such applications as Johnson's baby powder, sulfanilamide powder or zephiran chloride 1:5000. Greasy or oily preparations accelerated the onset of reaction, probably by maceration, chemical irritation and retention of bacteria with promotion of infection. Trauma, incidental to repeated applications, undoubtedly played some part in accentuating the reaction. The healing phase was not followed in detail, but in general, the untreated ears healed as promptly or sooner than did the medicated ears.

MEDICAL TREATMENT OF RADIODERMATITIS

Treatment of the skin following irradiation differs considerably in the different phases of reaction. In the early phase before vesiculation, the skin reaction is minimized by keeping it dry and applying no ointment or greasy substances. This opinion is based on the above animal experimentations and upon our clinical observations. The importance of keeping the skin dry and avoiding ointments has been emphasized by Windeyer³⁹ and by Finzi.¹⁶ Finzi advocates the use of talc, starch powders, calamine or zinc. A bland non-irritating powder, such as Johnson's baby powder, seems to reduce itching and lessen irritation by clothing. Areas covered by sterile dry gauze throughout the period of treatment have usually shown minimal reaction, according to our observations. All trauma should be avoided, such as scratching, ultraviolet, heat, irritating medications, etc. Re-application of adhesive to treated areas accentuates dermatitis, particularly in those pa-

tients who are sensitive to adhesive. Rubbing of the skin, as by a collar on the neck, frequently aggravates a dermatitis in that area, making it desirable to keep the garments loose and to place a layer of clean gauze over the treated area beneath the source of irritation.

The vesiculating phase of radiodermatitis invites infection. It is benefited by a bland wet dressing, such as normal saline or Burow's solution. The wet dressing cleanses the area by removal of exuded serum, desquamated skin, and other culture media. In case vesiculation is complicated by frank infection, sulfathiazole emulsion or one of the antibiotics,²⁶ such as penicillin or tyrothricin (0.5 mg. per cc.) in distilled water is advantageous. Streptomycin would be more effective in areas infected by gram negative bacilli. Moisture can be retained in the dressing by covering it with a rubber dam or cellophane. Exposure to the air between application of wet dressings seems to favor healing. Ointments applied to the area should have a water soluble base in order that they can be thoroughly removed with the wet packs. Nivea creme, alvangel, sulfathiazole creme, or tyrothricin ointment may be spread on sterile dressings before application in order to facilitate removal later. Necrotizing soft tissue can be eliminated to some extent through chemical debridement by allantoin 2 per cent, urea, azochloramide or activated zinc peroxide.

The medical treatment of ulceration persisting or recurring following radiotherapy has in the past been rather undependable. Various topical applications of poorly understood action and indeterminate effect have been advocated. Although ultraviolet therapy accentuates an acute radiodermatitis and blisters the atrophic skin of a chronic dermatitis, it has been used with some success in the treatment of postirradiation ulcers. Eidinow¹² reported improvement in 85 per cent of 74 cases following application of 10 e.d. of ultraviolet repeated at fourteen day intervals with coverage in the meanwhile by sterile adhesive. The bene-

ficial effect probably results from bactericidal action, superficial cautery, and some dilatation of vessels, but it leaves much to be desired. Electrocautery with a high frequency current promotes repair in small areas of ulceration through elimination of necrotic material and exposure of healthier epithelial and vascular tissue for regeneration. Fulguration is useful in the elimination of telangiectases.⁴ Aloe vera leaf and alvangel have been used in the treatment of radiation ulcers since 1935, when introduced by Collins.²² Chlorophyll ointment has been used in the treatment of post-irradiation reaction.¹⁸ It aids in the deodorization of wounds, and is said to promote regeneration. Estrin ointment has been used by Moseley²⁵ in 7 cases of post-irradiation ulcer with healing in 2 cases. Estrin supposedly promotes vasodilatation and epithelial regeneration. It would seem to have some promise physiologically in the treatment of perineal ulceration in women.

RADON OINTMENT IN RADONECROSIS

Radon ointment is reputedly the most effective non-surgical method for the treatment of post-irradiation ulcers,^{8,17,21,35,36} although we have had insufficient experience with this method to permit any personal evaluation. Radon ointment heals post-irradiation ulceration, provided it does not extend to bone or contain residual neoplasm.^{8,21,37} The method was first reported by Fabry¹⁵ in 1925, but it has been developed primarily by Uhlmann. Uhlmann reported a series of 70 cases with satisfactory healing in 68. Cooper and Robertson⁸ reported 69 cases of post-irradiation ulceration, of which 41 healed completely and 8 were improved under radon ointment therapy. Failure of the other 20 cases to improve was due to residual carcinoma. Low-Beer and Stone²¹ report 28 cases with full healing in 19; of the remaining 9 cases 4 were improved, 3 had residual carcinoma, 1 involved bone and radon was discontinued in 1 case.

The technique for applying radon oint-

ment* effectively is described by Uhlmann,³⁵ by Low-Beer and Stone,²¹ and by Cooper and Robertson.⁸ Radon gas is absorbed in vaseline in concentrations equivalent to 50 to 100 electrostatic units per gram of vaseline. It must be applied at the appointed time, since it undergoes deterioration to half its value in about four days. The ointment is applied by a spatula directly over the ulcerated area and is immediately covered with a piece of rubber dam, latex cap, oiled silk or cellophane, extending $\frac{1}{4}$ inch beyond the margins of the ulcer. This is sealed in place by overlapping strips of adhesive or scotch tape to prevent the escape of emanation into the air, and is left in place for eight hours. The treatment is repeated after an interval of seven days. The area is covered by boric acid ointment between applications. A favorable lesion may heal after two to four applications, while a more intractable lesion may require ten to sixteen applications.²¹ The radon bulb, delivering primarily beta radiation, was used by Duffy¹¹ in treatment of small keratoses and ulcers.

The mechanism whereby radon effects its benefit is not understood. Fricke and Williams¹⁷ suggest that the effect may be from isotopes created in the area through nuclear bombardment by alpha particles. The emission is primarily alpha and to some extent beta radiation. Alpha rays are said to be one hundred times as destructive as beta rays,³⁸ and although the effective penetration is limited to 0.1 mm., the radon gas does seem to penetrate through the tissues by diffusion. Radon treatment does promote, in some way, vascularization and epithelial regeneration. Low-Beer and Stone usually noted an erythema after the third or fourth week.

SURGICAL TREATMENT

The availability of competent surgical collaboration within our Department of Radiology through Dr. Breit has led us to frequently employ surgical repair. Radon

ointment might have been utilized had it likewise been as freely available to us. Surgical management,⁹ however, is indicated in the presence of sequestering bone and cartilage and for the elimination of residual or recurrent neoplasm. Surgical repair of a large ulcer usually provides more prompt exclusion of infection and more durable closure of skin than is to be anticipated following spontaneous repair under medical therapy. The general problem, surgical techniques and the adaptation of available methods of repair to particular regions and problems will be discussed in a following presentation.

SUMMARY

1. The influences which may contribute to persistent or recurrent ulceration following irradiation are: (a) constitutional disease—for example, hypoproteinemia, vitamin C deficiency, allergy, anemia, arteriosclerosis, uncontrolled diabetes and syphilis; (b) poor blood supply—whether the cause be systemic, regional, surgical, or irradiational; (c) infection of devitalized tissue; (d) foreign body action of devitalized bone, cartilage or fascia; (e) trauma—whether actinic, thermal, mechanical or chemical; (f) inadequate regeneration of tissue due to nutritional disorders or depression of cellular proliferation; (g) extensive lesions which exhaust regenerative capacity; and (h) residual or recurrent neoplasm.

2. The occurrence of necrosis following irradiation is to be reduced by promotion of general health, provision of proper nutrition, preservation of blood supply, control of infection, protection against trauma, treatment of lesions while small, and elimination of cancer by the first course of therapy as far as possible.

3. Experimental studies on acute radio-dermatitis in rabbits showed onset to be delayed and severity reduced by avoidance of greasy applications during the prevesicular phase, although the reaction was not aggravated by water or dry powder.

4. Clinical observations suggest that the

* The ointment is procurable from the Canadian Radium and Uranium Corporation, 726 Federal Street, Chicago, Illinois.

vesicular phase is benefited by sterile bland wet dressings and exposure to the air. A bland hydrophilic ointment or powder prevents adherence of dressings and reduces itching.

5. Infection is reduced by (a) lessened severity of radiodermatitis, (b) exclusion of bacteria by prompt closure of skin, (c) elimination of exudate and surface media by irrigations or wet dressings, (d) restraint of bacterial growth by bacteriostatic and antibiotic drugs.

6. Necrotizing tissues can be variously eliminated through: (a) oxidation by azochloramide or activated zinc peroxide, (b) chemolysis by allantoin or urea, (c) destruction by cautery with curettement, and (d) removal by excision or amputation.

7. Regeneration of epithelium is most effectively promoted by radon ointment, as advocated by Uhlmann and corroborated by others.

8. The general advantages, specific indications and essential details of surgical treatment of ulceration and deformity occurring after radiotherapy is presented in a subsequent publication.

9. Furthermore, it will be shown there that persisting or recurrent ulceration occurring after proper radiotherapeutic eradication of cancer is attributable primarily to inadequate recuperability of the tumor bed with precipitating trauma and infection rather than excessive total irradiation.

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REFERENCES

1. AHLBOM, H. Points regarding the "time factor" in roentgen irradiation with divided dosage. *Acta radiol.*, 1946, 27, 223-227.
2. BOWERS, W. F. Healing of wounds. *J. Lab. & Clin. Med.*, 1943, 28, 451-462.
3. BROWN, C. W., McCLINTOCK, L. A., and NEARY, E. R. Established surgical infections; treatment with urea-sulfanilamide mixture. *Am. J. Surg.*, 1945, 70, 4-12.
4. CANNON, A. B. The treatment of x-ray burns and other superficial disfigurements. *New York State J. Med.*, 1940, 40, 391-399.
5. COLWELL, H. A. X-ray and Radium Injuries; Prevention and Treatment. Oxford University Press, London, 1934.
6. COLWELL, H. A. The Method of Action of Radium and X-rays on Living Tissue. Oxford University Press, London, 1935.
7. CONVERSE, J. M., and HUNT, A. H. Factors influencing healing of wounds. *Tr. M. Soc. London* (1940-1943), 1945, 63, 76-86.
8. COOPER, A. G. S., and ROBERTSON, D. F. Treatment of post-irradiation ulcers by radon ointment. *M. J. Australia*, 1945, 1, 297-300.
9. DALAND, E. M. The surgical treatment of post-irradiation necrosis. *Am. J. ROENTGENOL. & RAD. THERAPY*, 1941, 46, 287-301.
10. DAVIS, H. H. Amino acids intravenously in surgical patients. *Nebraska M. J.*, 1945, 30, 51-54.
11. DUFFY, J. J. Irradiation keratoses and carcinoma. *Am. J. ROENTGENOL. & RAD. THERAPY*, 1939, 42, 540-544.
12. EIDINOW, A. The treatment of post-radiation necrosis by radiation therapy. *Brit. J. Dermat.*, 1941, 53, 171-176.
13. ELLINGER, F. The Biologic Fundamentals of Radiation Therapy. Elsevier Publishing Co., New York, 1941.
14. EWING, J. Tissue reactions to radiation. *Am. J. ROENTGENOL. & RAD. THERAPY*, 1926, 15, 93-115.
15. FABRY, J. Behandlung einer schweren Röntgenverbrennung der Hände mit Radium und Doramadalsalbe. *Med. Klin.*, 1925, 21, 1498.
16. FINZI, N. S. The management of x-ray reactions. *Brit. J. Radiol.*, 1942, 15, 192-193.
17. FRICKE, R. E., and WILLIAMS, M. M. D. Radon ointment treatment of irradiation ulcers. *Radiology*, 1945, 45, 156-161.
18. HOLMES, G. W. and MUELLER, H. P., Treatment of post-irradiation erythema with chlorophyll ointment. *Am. J. ROENTGENOL. & RAD. THERAPY*, 1943, 50, 210-213.
19. KAPLAN, T. The allantoin treatment of ulcers. *J.A.M.A.*, 1937, 108, 968-969.
20. LERICHE, R., and FONTAINE, R. Résultats de la sympathectomie péri-artérielle dans le ulcères de la radiodermite. *Rev. de chir.*, 1930, 68, 167-176.
21. LOW-BEER, B. V. A., and STONE, R. S. Treatment of late post-irradiation ulcers with radon ointment. *Radiology*, 1946, 46, 149-158.
22. MANDEVILLE, F. B. Aloe vera in the treatment of radiation ulcers of mucous membranes. *Radiology*, 1939, 32, 598-599.
23. MARCUSE, W. Nachtrag zu dem Fall von Dermatitis und Alopecie nach Durchleuchtungsversuchen mit Röntgenstrahlen. *Deutsche med. Wchnschr.*, 1896, 22, 681-682.
24. MOHS, F. E. Chemosurgical treatment of cancer

- of the ear: microscopically controlled method of excision. *Surgery*, 1947, 21, 605-622.
25. MOSELEY, J. E. Contribution to the treatment of post-irradiation necrosis. *Radiology*, 1945, 44, 262-265.
 26. NETER, E. Penicillin and other antibiotics as chemotherapeutic agents in wound infections. *New York State J. Med.*, 1945, 45, 1982-1986.
 27. PULLINGER, B. D. Causes of cell death in irradiated human tissue. *J. Path. & Bact.*, 1932, 35, 527-540.
 28. RHOADS, J. E., FLIEGELMAN, M. T., and PANZER, L. M. Mechanism of delayed wound healing in the presence of hypoproteinemia. *J.A.M.A.*, 1942, 118, 21-25.
 29. SANDSTRÖM, O. Subsequent degenerations after fractional protracted roentgen irradiation. *Acta radiol.*, 1943, 14, 289-294.
 30. SCHWEITZER, A. The external application of pancreas hormone in dermatology with special reference to the treatment of ulcer cruris and roentgen ulcer. *Urol. & Cutan. Rev.*, 1936, 40, 333-335.
 31. SEEVERS, M. H. Recent advances in bacterial chemotherapy. I. The sulfonamides. *Am. J. Orthodont. & Oral Surg.*, 1947, 33, 185-192.
 32. SEEVERS, M. H. Recent advances in bacterial chemotherapy. II. The antibiotics. *Am. J. Orthodont. & Oral Surg.*, 1947, 33, 193-200.
 33. SPOTTS, S. D., and DAVIS, J. B. Allantoin-sulfanilamide ointment in surgery. *Am. J. Surg.*, 1945, 69, 4-8.
 34. SUNDERLAND, D. A., and BINKLEY, J. S. Use of zinc peroxide in infected tumors and radiation necrosis. *Radiology*, 1940, 35, 606-615.
 35. UHLMANN, E. Treatment of injuries produced by roentgen rays and radioactive substances. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1939, 41, 80-90.
 36. UHLMANN, E. Significance and management of radiation injuries. *Radiology*, 1942, 38, 445-452.
 37. UHLMANN, E., and GROSSMAN, A. Use of radon ointment as a means of differentiation between radionecrosis and recurrent carcinoma. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 620-623.
 38. WARREN, S. Histopathology of radiation lesions. *Physiol. Rev.*, 1944, 24, 225-238.
 39. WINDEYER, B. W. Radiation reactions. *Brit. J. Radiol.*, 1942, 15, 236-237.
 40. WOLBACH, S. B. The pathological histology of chronic x-ray dermatitis and early x-ray carcinoma. *J. Med. Research*, 1909, 21, 415-449.



A MASTER FACIAL CAST FOR RIGID PORTAL DELIMITATION IN ROENTGEN THERAPY OF CANCER ABOUT THE FACE

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THE importance of precise technique in roentgen therapy is accepted as axiomatic. Just what constitutes precise technique, however, is quite a variable matter. There are those who deliver roentgen irradiation to cancer of the skin through cylinders in direct contact with the face. There are others who fashion a lead cut-out and apply the cylinder to the opening in the lead sheet. It is not the purpose of this paper to discuss the merits of one method over the other. The latter method is that approved by the author. However, lead cut-outs as they are ordinarily used fit the patient's part so poorly that the resultant unstable portal often defeats the purpose for which it is used. In the experience of this clinic, measured by present standards, direct application of cylinders or the use of poorly fitting, roughly fashioned shields can hardly be considered precision therapy.

Success in treating with roentgen rays certain complicated lesions of the skin of the face and of the oral cavity depends to a great degree on proper portal size, exact reduplication of technique, treatment after treatment, protection from undesired irradiation, etc. The difference between success and failure can often be traced to the therapist's ingenuity, or lack of it, in devising safe and adequate means of delivering therapy to a *rigidly* controlled portal. The novice interested in radiation therapy too often feels that the only significant data necessary to the proper treatment of a given case are the dosage factors and total dosage to be employed. This is knowledge easily acquired. More difficult of acquisition, and much more important, is the development of the skill in treatment planning which is so necessary if the desired total dose is to be delivered safely to

the exact area intended. This applies to tumors in any situation, but is of greater importance when considered in relation to epidermal carcinoma because of the relatively small portals used. The treatment of cancer of the skin is too often regarded and professed to be a simple problem by men of wide experience. This view frequently misleads those of meager experience to believe that skin cancer is a problem simple enough to be managed by anyone. Forty per cent of cancers of the skin seen in this clinic have received previous unsuccessful treatment elsewhere.¹ It may be true that many cases of skin cancer are relatively simple problems. Yet the high percentage of inadequately treated cases indicates that many do require the most expert and precise therapy to effect a successful result.

It must be remembered that skin cancers although accessible are by no means radiosensitive; many are radioresistant. The delivery of cancer lethal dosage to these resistant lesions demands precision therapy of the highest order.

I believe that one of the fundamental factors involved in successful skin cancer therapy is the ability to maintain a rigid portal. In other words, it is essential that roentgen therapy is actually delivered to the precise area selected for treatment, not for one treatment, but for every treatment! How can this be done?

Admittedly, the ideal method would be the preparation of a face mask of necessary size from a direct cast made from the face of each individual patient. From such a cast made of plaster or artificial stone a mask could be made which would conform accurately to the face contours of the patient. To make such a mask for every patient, however, is costly, time-consum-

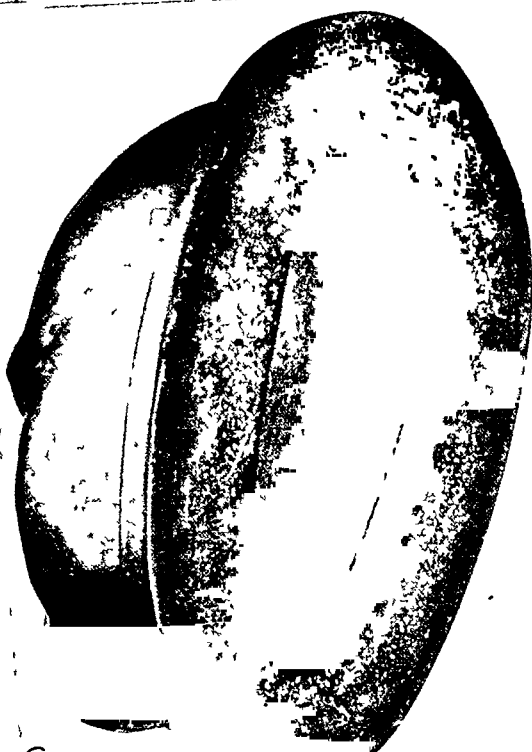
*A**B**C**D*

FIG. 1. Several views of the Kirksite universal face cast: *A*, front view; *B*, side view; *C*, back view; *D*, the universal cast with a typical face mask swaged over it. Such a mask can be used for treating lesions of the lid, canthus, and nasolabial area.

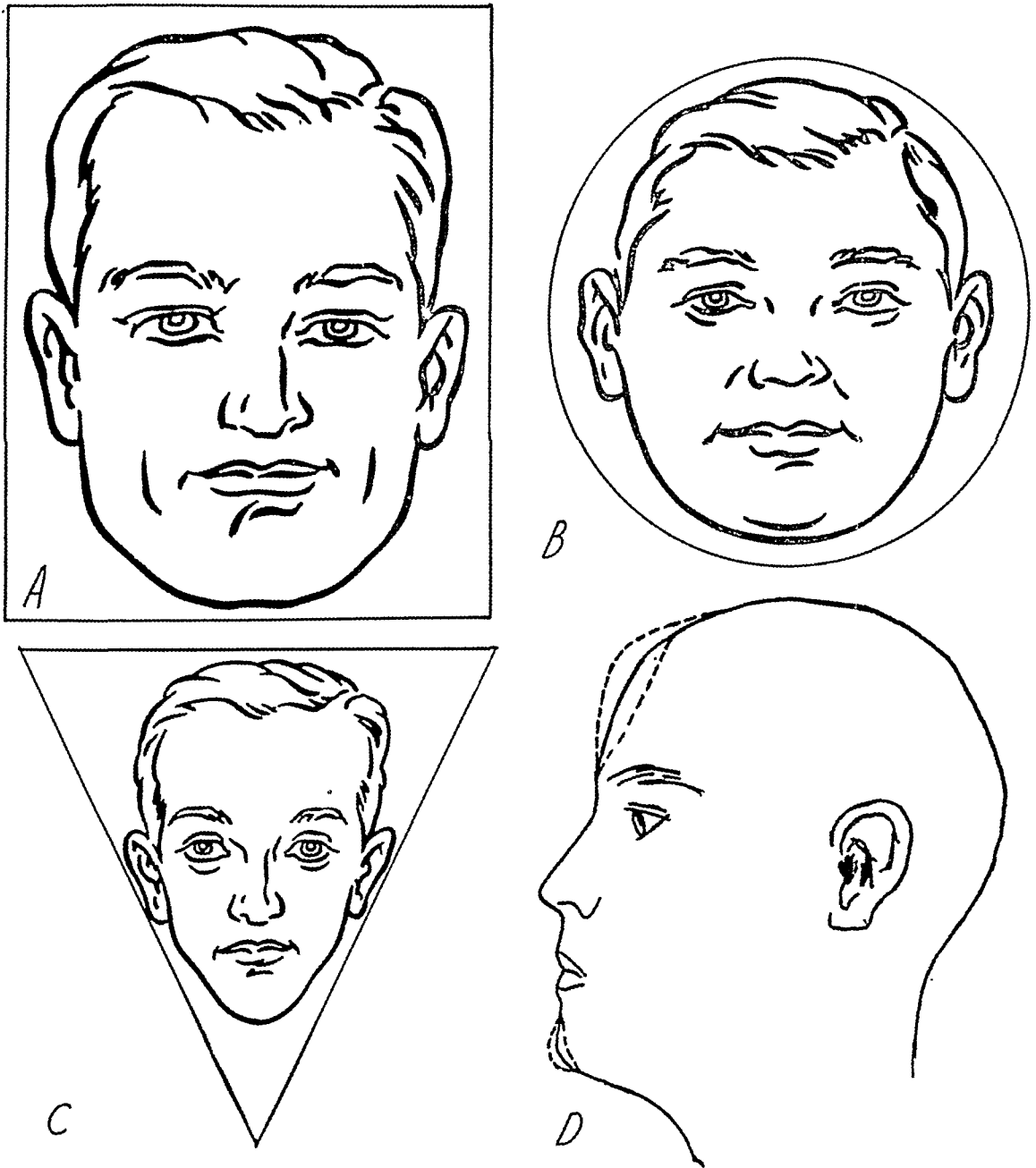


FIG. 2. The basic face types: *A*, basic square face; *B*, basic ovoid face; *C*, basic tapering face; *D*, face variations in lateral view. (Courtesy of the *Dental Digest* and Dr. P. P. Gross.)

ing, and altogether impracticable.

Rigid reduplication of technique with adequate protection can be done most practically by the use of especially prepared lead face masks swaged over a universal facial cast* (Fig. 1). The Kirksite

universal cast represents a practical compromise. The subject used in the development of our cast was selected only after careful study of many face forms and represents a composite of the three fundamental face types, namely, the square face, the ovoid face, and the tapering face³ (Fig. 2).

* Made of Kirksite, an alloy composed of zinc, aluminum and lead. The significant dimensions of the cast are as follows: 13 cm. from base to forehead; 13.5 cm. from base to tip of nose; 9 cm. from base to chin. The base is 1.5 cm. thick. The weight of the cast is 28 pounds.

The process by which the cast is made is described elsewhere.² The technique of manufacturing the cast will be sent to anyone who desires this information.



FIG. 3. *A*, a typical case of epidermoid carcinoma involving the inner canthus and left lower lid. *B*, the mask with an awl hole centrally placed in relation to the underlying lesion. *C*, the mask with the opening enlarged only to the actual size of the lesion. The white line about the opening represents the size and shape of the final portal. The mark is usually made with an awl. *D*, final portal cut out and properly fitted. Note that a portion of the eye is included in the portal.

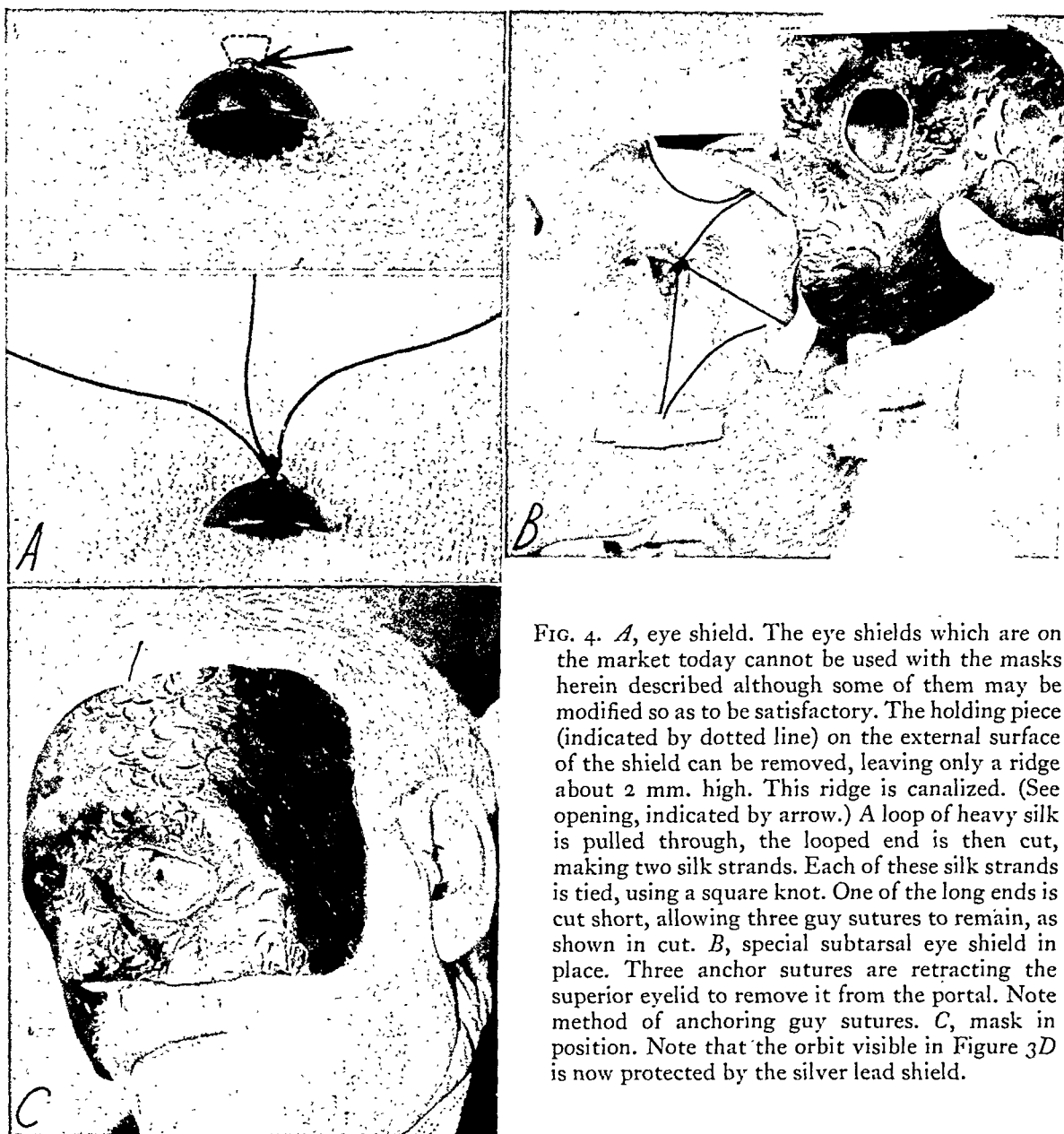


FIG. 4. *A*, eye shield. The eye shields which are on the market today cannot be used with the masks herein described although some of them may be modified so as to be satisfactory. The holding piece (indicated by dotted line) on the external surface of the shield can be removed, leaving only a ridge about 2 mm. high. This ridge is canalized. (See opening, indicated by arrow.) A loop of heavy silk is pulled through, the looped end is then cut, making two silk strands. Each of these silk strands is tied, using a square knot. One of the long ends is cut short, allowing three guy sutures to remain, as shown in cut. *B*, special subtarsal eye shield in place. Three anchor sutures are retracting the superior eyelid to remove it from the portal. Note method of anchoring guy sutures. *C*, mask in position. Note that the orbit visible in Figure 3*D* is now protected by the silver lead shield.

Experience with the Kirksite cast has shown the above-mentioned direct plaster cast technique to be entirely unnecessary.

Despite the fact that a master or universal cast is employed in making masks for all patients, not a single case has been encountered, either adult male or female, which could not be properly fitted with only minor alterations. Nevertheless, it must be conceded that in rare instances this mask may prove unsatisfactory.

The face mask is made by placing a sheet of lead over the Kirksite master-

casting and carefully hammering the lead with a machinist's ball peen hammer, so that the contours of the cast are transferred in full detail to the mask (Fig. 1*D*). Special attention is required at the bridge of the nose, about the nares, and the canthi of the eyes. The sheet lead measures $\frac{3}{8}$ inch in thickness.* Not more than two-thirds of the patient's face, preferably less, should be covered by the mask. It is important

* It has been found that if lighter material is used, the hammering process may thin out the lead to a point where protection is inadequate.

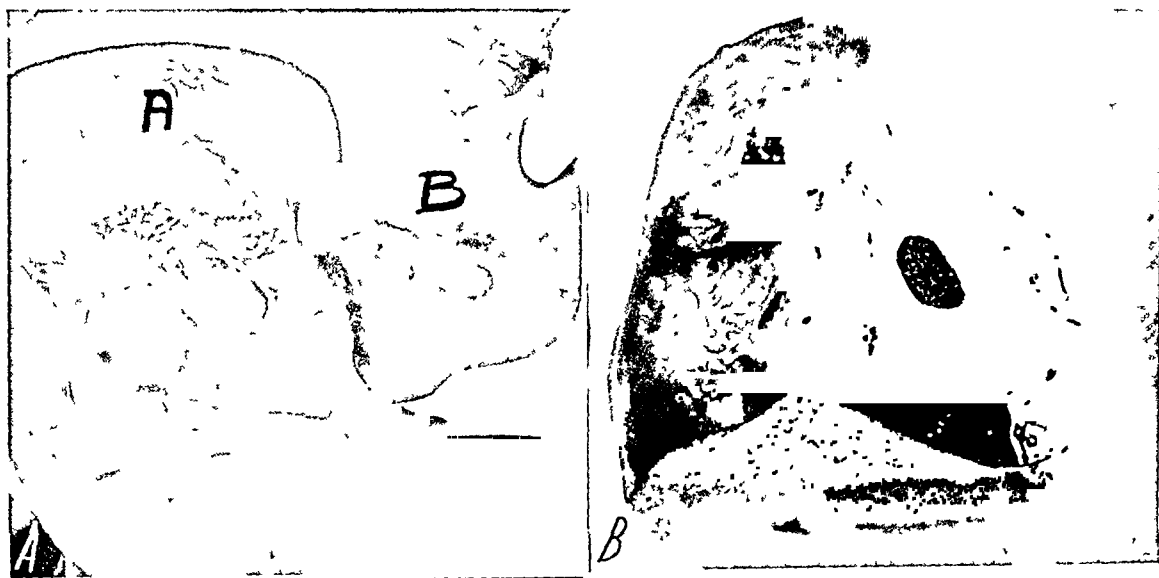


FIG. 5. *A*, face mask with original portal; (*B*), field reduction mask. Note smaller sized portal. *B*, field reduction mask (shown in black) has been properly placed over the original mask. Adhesive tape fixation is not shown. *C*, reverse view of mask. The area in white represents the extent by which the field was reduced in this particular case. In certain types of cases the field may be reduced three or four times before completion of therapy.



FIG. 6. Example of a mask used in treating multiple cancer—in this instance, cancer of the right lower lid, right lateral nasal area, and left inner canthus.



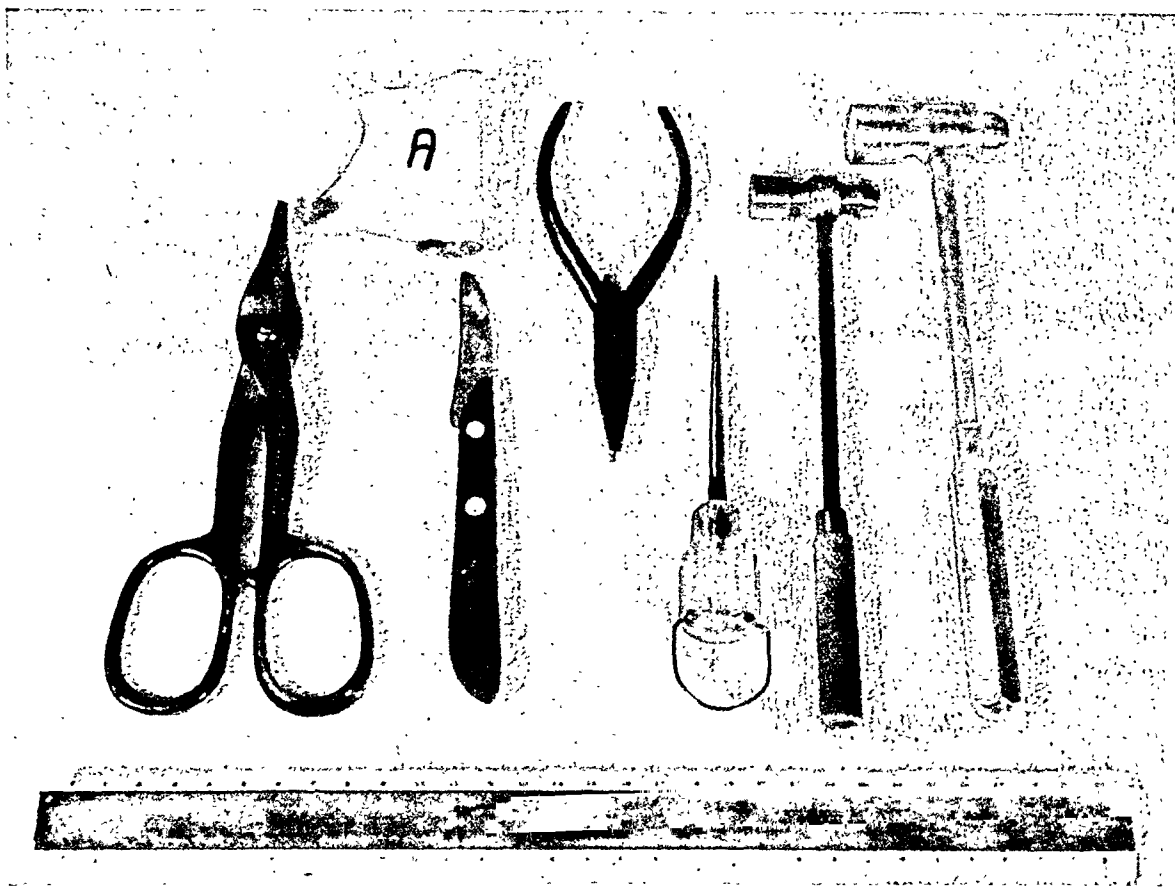


FIG. 7. Basic equipment necessary for the preparation of masks. Note that ball peen hammers of two sizes are used—a heavier one for the preliminary gross work and a lighter one for the detailed work. Material marked *A* is a small roll of chamois skin.

not to exceed this percentage relationship for it must be appreciated that the cast from which the mask is made is not a perfect replica of the patient's face, and that significant variations in faces are most marked in the position of the forehead and lower jaw in relation to a vertical plane (Fig. 2*D*).

After completion of the mask, it is fitted over the subject and the portal is cut out. The method employed in cutting the portal or opening is a variable matter. My technique is as follows: The center of the lesion is carefully determined and a punch-hole is made by means of an awl (with the mask away from the patient) (Fig. 3, *A* and *B*); then this is enlarged gradually by a small sharp knife to the point where further increase in size can be accomplished by a small 6 inch tin snip and/or sharp knife.

The aperture is then increased to the approximate size and shape of the lesion to be treated. The final desired portal is scratched about the opening by the use of an awl (Fig. 3*C*) and is gradually cut out, using a tin snip (Fig. 3*D*). It is better to under-cut, testing frequently, than to make the portal over-large. One can always increase and modify as necessary until satisfied that the portal is correct, both as to shape and size. One should not be disturbed if the edge of the cut-out is not in direct contact with the skin when first tested. Minor adjustments with a ball peen hammer, thumb pressure, etc. are necessary to obtain an accurate fit. The edges of the cut-out are carefully smoothed by means of a blunt instrument and finally rubbed with a piece of chamois and the mask fitted to the patient. The patient is made ready for treatment (Fig. 4,

A, B and C). Treatment is then delivered, using a cylinder which will more than cover the opening. An extra margin of cylinder of about 0.5 cm. to 1.0 cm. is adequate.

In the process of treatment, it may be desirable at some stage to reduce the size of the portal. This can easily be done in the following manner: A piece of sheet lead is used, preferably $1/32$ inch in thickness, and of a size which will overlap the opening already present by 2 or 3 cm. The lead is placed on the universal cast at the site of the present portal and hammered into the contour of the part. The desired portal of reduced size is cut out, the reduction mask fitted to the main mask, adjusted by thumb pressure, and taped into position (Fig. 5, A, B, C and D).

A mask once used need not be discarded as it may be employed for a patient who presents himself with a lesion of the opposite side, or, for that matter, in any situation which does not encroach upon the cut-out already present (Fig. 6).

Prior to the use of this cast, more than an hour had been devoted in devising shields in certain cases. Today, these masks can be hammered out by residents or technicians and an adequate supply can always be at hand (Fig. 7).

The method of portal delimitation described greatly simplifies treatment in offices where therapists strive for precise treatment portals in regions such as the

lids, canthi, and nose. This method can also be used in planning portals for treatment of carcinoma elsewhere—for example, intraoral carcinoma, carcinoma of the accessory sinuses, and carcinoma of the nasal cavity.

SUMMARY

A technique for rigid portal control by the use of specially prepared lead masks swaged over a universal facial cast made of zinc, aluminum and lead (Kirksite) is presented. The method simplifies roentgen therapy, improves technique, and requires no special skill to master. The cast can be made by enlisting the aid of a dentist interested in moulage work. It is possible that a similar master cast may be purchased, already made, in the near future.

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REFERENCES

1. CASTIGLIANO, S. G. Treatment of Epidermoid Carcinoma of the Skin and Its Appendages in Diseases of the Skin. By John B. Ludy. Edited by Sigmund S. Greenbaum. F. A. Davis Co., Philadelphia.
2. CASTIGLIANO, S. G., and GROSS, P. P. Master metal facial cast for swaging lead masks in the treatment of carcinoma of the skin of the face. *Am. J. Orthodontics*, 1947, 33, 319-325.
3. GROSS, P. P. Relation of facial forms to osseous structures surrounding the teeth. *Dental Digest*, 1942, 48, 228-230.



HERNIATION OF THE CEREBRAL VENTRICLES*

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THERE are four regions in the cerebral ventricular system which tend to "blow out" or herniate when the cerebrospinal fluid flow has been blocked within the ventricular system. These regions are the anterior and the posterior walls of the third ventricle, the posteromedial floor of the lateral ventricle near the origin of the temporal horn, and the superior portion of the fourth ventricle. It is apparent that the latter three areas are in close proximity and it will be shown that despite their different origin they are similarly located when fully developed.

For many years those who have been interpreting roentgenograms made after the procedure of ventriculography have noted unusual enlargement of the third ventricle in obstructive internal hydrocephalus. Dilatation of the anterior wall of the third ventricle into the cisternae chiasmatis and interpeduncularis is observed frequently. This type of dilatation is usually most marked in the regions of the optic and infundibular recesses (Fig. 12, 20 and 22). It is well recognized clinically that this type of hydrops of the third ventricle causes pressure upon the upper surface of the optic chiasm which may lead to a bitemporal blindness.⁴

POSTERIOR HERNIATION OF THE THIRD VENTRICLE

Dilatation and subsequent herniation of the posterior wall of the third ventricle into the cisterna ambiens and through the incisura tentorium has received little attention. Childe and McNaughton¹ in 1942 and Pennybacker and Russell⁶ in 1943 each reported a case of herniation or rupture of the lateral ventricle and in their discussions the similarity of posterior protrusion of the third ventricle was noted. More recently

Wilson and Lutz¹⁰ have stated that simple aqueduct stenosis results occasionally in posterior herniation of the third ventricle.

A thorough knowledge of the anatomy of the third ventricle is essential for proper understanding of the pathologic changes involving it. The third ventricle is a midline cavity situated between the thalami and the hypothalami of the diencephalon. The anterior pillars of the fornix form a small portion of the lateral wall anteriorly. Anterosuperiorly it communicates with the lateral ventricles by means of the interventricular foramina of Monro and posteriorly the aqueduct of Sylvius connects it with the fourth ventricle (Fig. 1 and 2). The roof of the third ventricle is lined by the lamina chorioidea epithelialis, which covers the tela chorioidea and is attached posteriorly to the habenula and penial body (Fig. 1 and 2).

The anterior wall is formed by the pillars of the fornix, the anterior commissure, the rostral lamina of the corpus callosum and the lamina terminalis. In the floor, from before backward, are found the optic recess, between the lamina terminalis and optic chiasm, the optic chiasm, the tuber cinereum with the infundibular recess anteriorly, the corpora mammillaria, and the cerebral peduncles and intervening posterior perforated substance. Posteriorly, above the aqueduct of Sylvius the wall is formed by the anterior end of the lamina quadrigemina, the posterior commissure (Fig. 12), the pineal body, containing pineal recess, and the habenular commissure, with the suprapineal recess just above it (Fig. 1 and 2). Frequently the third ventricle is crossed in its mid-portion by a mass of gray matter called the middle commissure or massa intermedia. The latter varies considerably in size and may

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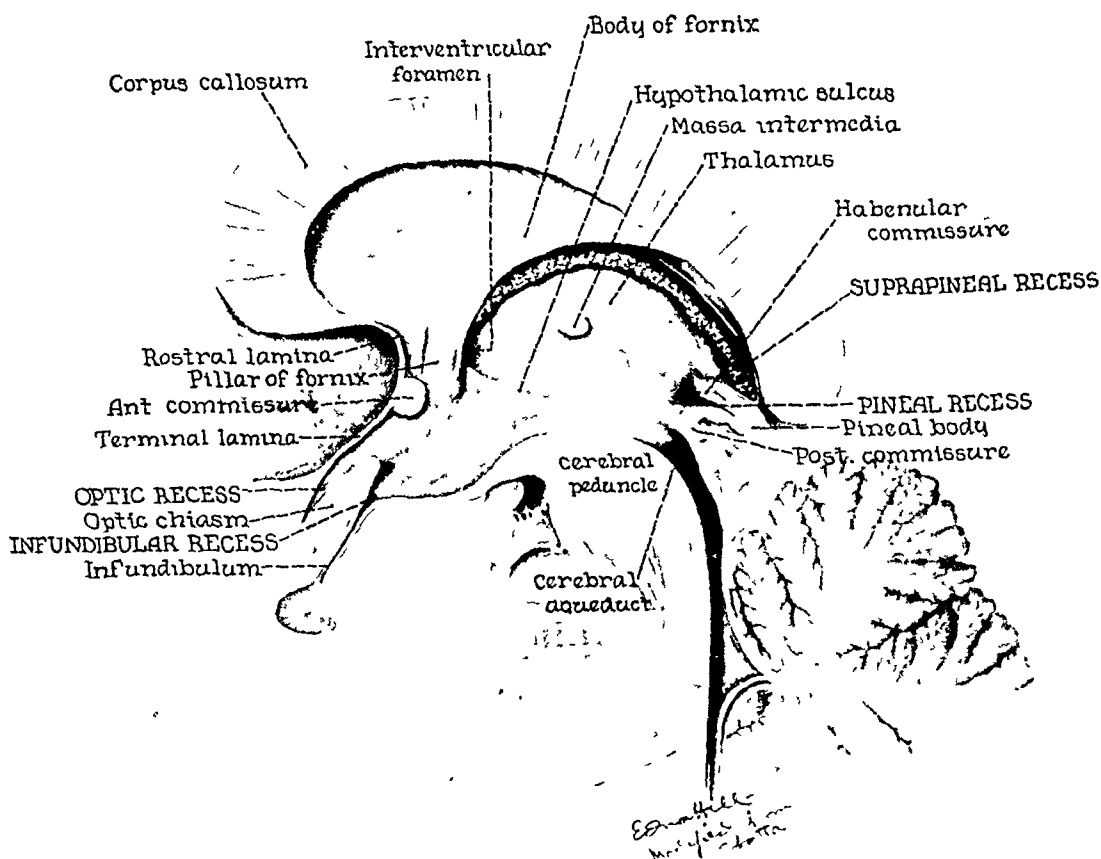


FIG. 1. Sagittal section of the normal third ventricle.

be absent.^{2,8} Roentgenologically the so-called normal third ventricle varies considerably in size and shape, especially in the erect posteroanterior and anteroposterior projections. The greatest width of the third ventricle varies from 2 to 10 mm. It may appear as a narrow 2 to 4 mm., slit-like shadow in the midline beneath the lateral ventricles. Because of the ventral swing of the anterior horns of the lateral ventricles the superior portion of the third ventricle may appear to be between the shadows of the lateral ventricles (Fig. 3 and 4). The massa intermedia may be visible in some of the very narrow third ventricles (Fig. 4). The intermediate group of normal third ventricles, i.e., greatest width 4 to 8 mm., tend to have an elliptical or bottle shape (Fig. 5 and 6). In this group the pineal gland can be identified in the lower portion of the shadow of the third ventricle (Fig.

6). Occasionally the narrow superior portion of the third ventricle gives its shadow an appearance comparable to that found in brain sections made through the optic chiasm. It is noteworthy that in this region, the upper portion of the anterior part of the third ventricle is bounded laterally by the anterior pillars of the fornix and the anterior thalamus⁹ (superimposed) (Fig. 6). In the larger third ventricles one can usually differentiate the component parts of the third ventricle shadow in the posteroanterior projection. The oval or droplet-shaped darker portion of the shadow represents air in the middle and posterior portions of the third ventricle.⁹ In this region the lateral walls are formed by the thalamic nuclei (Fig. 7 and 8). With complete drainage of the cerebrospinal fluid from the third ventricle and with proper positioning the less dark and lower portion of the third



FIG. 2, *A* and *B*. (*A*) Lateral ventriculogram of a moderately dilated third ventricle; *a*=middle commissure; *b*=body of fornix; *c*=foramen of Monro; *d*=rostral lamina of corpus callosum; *e*=anterior commissure, *f*=lamina terminalis; *g*=optic chiasm; *h*=tuber cinereum; *i*=region of mammillary bodies; *j*=cerebral peduncles; *k*=aditus of aqueduct of Sylvius; *l*=posterior commissure; *m*=partially calcified pineal gland; *n*=region of habenula.

(*B*) Posteroanterior projection showing a bottle-shaped third ventricle.



FIG. 3. In this encephalogram, one sees a small third ventricle shadow, *a*, in an eleven year old boy with epilepsy of four years' duration. The greatest width of the third ventricle shadow is 2 mm. Note the small amount of air beneath the tentorium cerebelli (arrows).

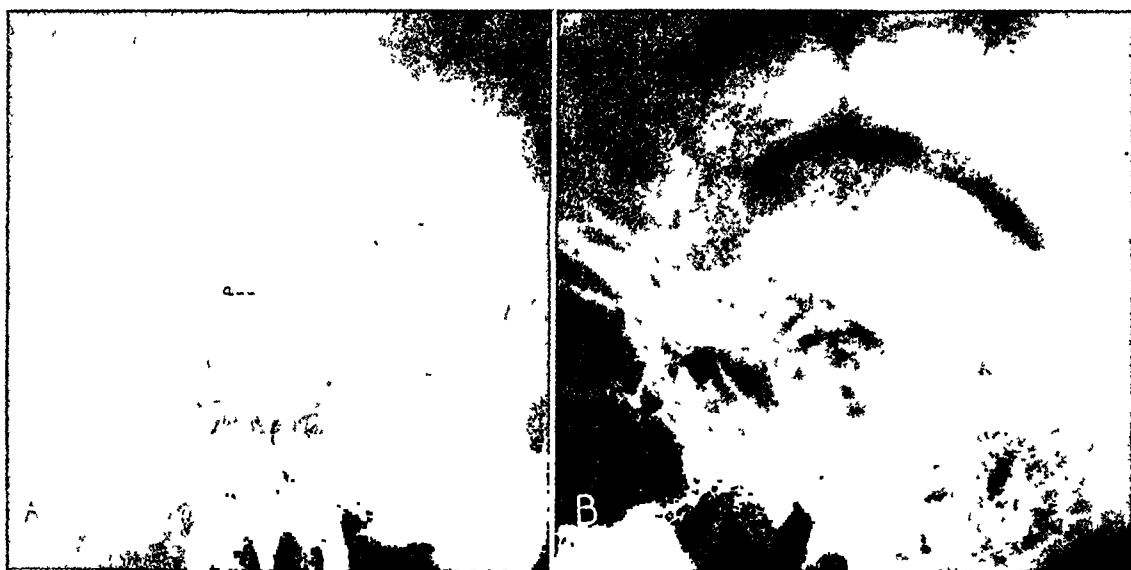


FIG. 4, *A* and *B*. Encephalograms of an eight year old girl with incontinence and polydipsia for four months. (*A*) The third ventricle shadow is small but the middle commissure, *a*, is visible. Note the shadows do not meet in the midline suggesting a lack of fusion of the masses which form the commissure. (*B*) The third ventricle shadow is only faintly outlined in the lateral projection.

ventricle shadow may be visualized and apparently represents air in the anterior portion of the third ventricle. This portion



FIG. 5. Posteroanterior projection of an encephalogram in a thirty-five year old man with right supra-orbital headache and a right eyelid ptosis for seven weeks. The third ventricle shadow, *a*, is elliptical and well outlined except for the inferior or hypothalamic portion, *b*, which is only faintly visible.

is bounded laterally by the structures of the hypothalamus (Fig. 8). With a change in positioning the relationship of the component parts of the shadow is changed. For instance, with the head somewhat extended the lower portion of the anterior third ventricle and the posterior droplet-shaped portion are superimposed (Fig. 7). If there has been incomplete drainage, the lower anterior portion may not be visualized and one will see only the droplet-shaped portion of the third ventricle (Fig. 9).

In the erect anteroposterior projection, using the modified Stewart position, the shadow of the third ventricle is elongated and usually spindle-shaped. In this view it is projected upward between the shadows of the lateral ventricles to an even greater extent than in the posteroanterior projection (Fig. 10).

In the erect and horizontal lateral projections the shadow of the "normal" third ventricle is usually not well visualized unless the greatest width of the ventricle, as measured in the posteroanterior projection, approaches the upper limits of normal, i.e., 8 to 10 mm. (compare Fig. 4 and 8). When there is good visualization in the lateral

projection the upper portions of the pillars of the fornix are outlined by air in the foramina of Monro which are immediately posterior (Fig. 2). The body of the fornix can be seen as a band of increased density arching posteriorly from the foramina of Monro (Fig. 2 and 8). This portion of the fornix fuses posteriorly with the splenium of the corpus callosum (Fig. 8) and the crura of the fornix which continue ventrally along the posterior ends of the thalami. The

anterior hypothalamic portion of the normal third ventricle is frequently cup or tulip shaped (Fig. 8), but with slight enlargement tends to have a rhomboid outline (Fig. 2). With adequate drainage, the various structures of the floor of the third ventricle are visible in the erect as well as the horizontal lateral projections. Anteriorly the optic and infundibular recesses are not usually well visualized unless the third ventricle is slightly dilated, in which instance the re-

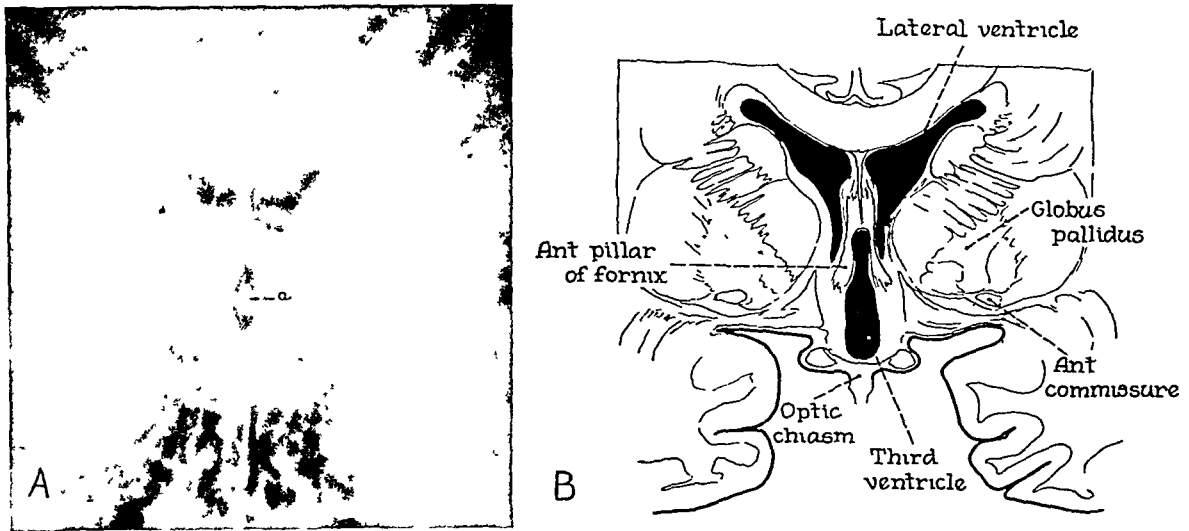


FIG. 6, *A* and *B*. (*A*) Encephalogram of a thirty-seven year old man with intermittent right temporal headache for nineteen years. The third ventricle shadow is bottle-shaped and a calcified pineal gland, *a*, can be visualized in the lower portion of the third ventricle shadow. The upper more narrow portion of the shadow represents air in the superior portion of the anterior part of the ventricle. (*B*) Sketch of the brain stem in the region of the anterior pillars of the fornix for comparison with (*A*). The lateral boundaries of this portion of the third ventricle are formed by the superimposed shadows of the anterior pillar of the fornix and the anterior thalamus.

anterior commissure is frequently visualized producing a small defect and area of increased density in the anterosuperior margin of the third ventricle (Fig. 2 and 8). Beneath it the lamina terminalis may be seen extending downward forming a narrow white line which limits the hypothalamic portion of the third ventricle anteriorly. It is about 1 mm. wide and is outlined anteriorly by air in the cisterna lamina terminalis and posteriorly by air in the third ventricle (Fig. 8). In the moderately enlarged third ventricle the lamina terminalis is elongated (Fig. 2). As the third ventricle continues to enlarge, the lamina terminalis becomes paper thin and transparent. The

cesses may be shallow and rounded (Fig. 2). With further dilatation finger-like projections may be produced in the region of the recesses (Fig. 20). The tuber cinereum is usually visible as it extends posteriorly from the region of the recesses to the shadows of the mammillary bodies and cerebral peduncles (Fig. 2). The upper border of the cerebral peduncles arches posteriorly, parallel but somewhat posteriorly to the arc of the fornix above it. Immediately above the opening of the aqueduct of Sylvius the round shadow of the posterior commissure is frequently seen. When calcified the pineal gland is readily visible above and behind the posterior

commissure (Fig. 2). The suprapineal recess is occasionally demonstrable as a somewhat variable finger-like posterior projection of the third ventricle (Fig. 8). When present the middle commissure is readily visible in the mid-portion of the third ventricle (Fig. 2 and 8).

The delayed twenty-four hour examination is usually of little value in examination of the third ventricle because of absorption of the air and re-accumulation of the cerebrospinal fluid. Rarely the air in the third ventricle is not absorbed and it remains

the enlarged third ventricle shadow will be hexagonal (Fig. 15). In this type there is proportionately less anterior "ballooning" of the third ventricle as seen in the lateral projections. The greatest diameter of the third ventricle in the diamond and hexagonal types is probably in the region of the hypothalamic sulcus (Fig. 1), which is ventral to the massa intermedia and above which the thalamus forms the lateral walls of the third ventricle. The subthalami and hypothalami form the lateral walls below the hypothalamic sulci.⁷ In the

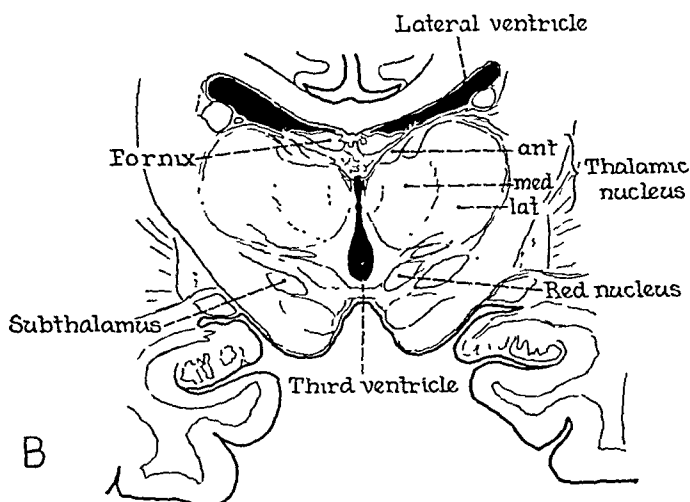


FIG. 7, *A* and *B*. (*A*) Third ventricle of an eight year old girl with ataxia, vomiting, and headache for four weeks. The lower droplet-shaped portion of the third ventricle shadow, *a*, represents air in the middle and posterior portions of the third ventricle. (*B*) Sketch of brain stem for comparison with (*A*).

visible in the delayed examination (Fig. 11). The significance of this is as yet uncertain.

As the third ventricle becomes extensively enlarged it assumes various shapes in the posteroanterior projection, depending upon the degree of dilatation of the various portions of the ventricle. If the anterior and posterior portions are equally enlarged, a sausage-like shadow results (Fig. 12). Another type of symmetrical enlargement results in a circular shadow (Fig. 13). If there has been greater enlargement of the mid-portion with less dilatation of the superior and inferior portions there is a tendency to a diamond shape with rounded angles (Fig. 14), an exaggeration of the normal type seen in Figure 7. Occasionally

hexagonal types the wide diameter at the superior angles is in the region of the medial end of the transverse fissures of the cerebrum.⁷ The transverse fissure of the cerebrum extends laterally between the inferolateral margin of the fornix and the dorsomedial margin of the thalamus. It separates the hemispheres from the diencephalon and contains the tela chorioidea from which are formed the choroid plexuses of both the lateral and third ventricles. Embryologically the transverse fissure is formed by the folding back of the hemispheres over the diencephalon.

When the posterior and superior portions of the third ventricle are more susceptible to dilatation than the remaining portion, a triangular shadow results (Fig. 16). An-



FIG. 8, *A* and *B*. Encephalograms of a four year old boy with athetoid tremors of the left arm and head of six weeks' duration. In (*A*), the posteroanterior projection, the large oval darker portion of the third ventricle shadow, *a*, represents air in the middle and posterior portion of the third ventricle (see Fig. 7*B* for comparison). The less dark lower and smaller portion of the shadow *b*, represents air in the lower anterior part of the third ventricle. The greatest width of the third ventricle shadow is approximately 10 mm. In the lateral projection (*B*), the third ventricle is fairly well visualized. Note the suprapineal recess, *c*, and the body of the fornix, *d*, in the lateral projection. The rather large middle commissure, *e*, and anterior commissure, *f*, are well visualized. The lamina terminalis is visible at *g*.

other type of dilatation results in a modified triangular or pentagonal shadow (Fig. 17). Needless to say there are other transitional forms such as the "inverted bottle" or flask-type (Fig. 18). The middle commissure density is small or absent in all of the markedly dilated third ventricles (Fig. 12 and 18). In the anteroposterior projection the "stretched" middle commissure may be seen as a narrow band of density extending across the third ventricle shadow (Fig. 22).

As the third ventricle continues to enlarge, posterior herniation is likely to take place. The following cases illustrate the development of such herniations.

CASE REPORTS

CASE I. The patient was a thirty-one year old white female file clerk complaining of generalized paralysis for three months. Three and a half months before admission she developed fever, nausea, vomiting, and chills. Her family physician diagnosed streptococcic sore throat and gave her sulfanilamide. She then improved but noticed tingling in her left shoulder and

legs. Five weeks after the onset of her illness she returned to work but noticed weakness of the left arm and leg. She then developed a second sore throat with fever and a paralysis of her left hand, arm, leg, and face, successively. During that time she received sulfanilamide but became progressively worse. Upon admission she was mentally confused and somewhat euphoric.

Physical examination revealed a pale, emaciated, uncooperative, chronically and acutely ill female. The left pupil was larger than the right and there were three diopters of papilledema bilaterally with exudates and small hemorrhages in the retina of the left eye. The tonsils were enlarged and inflamed. A marked tachycardia was also present. A left hemiplegia was noted and there was weakness and tremor of the right extremities.

Preliminary laboratory studies revealed a slight leukocytosis and markedly increased sedimentation rate. One week after admission the tonsillitis became more severe and she was started on sulfathiazole locally. A throat culture revealed hemolytic *Staphylococcus aureus* and a moderate number of hemolytic streptococci. A lumbar puncture showed a cerebrospinal fluid pressure of 230 mm. of water but no

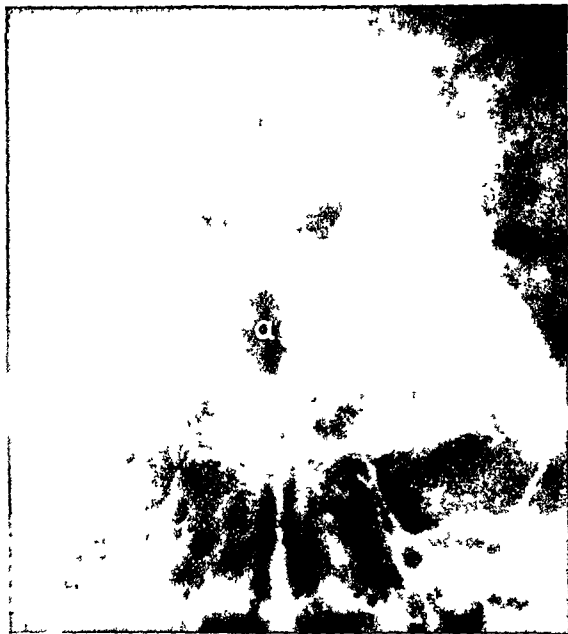


FIG. 9. Encephalogram showing the third ventricle of a forty-eight year old white male with occipital headache and bilateral tinnitus for three months. Only the droplet-shaped portion of the third ventricle shadow, *a*, is visible because of incomplete drainage of the hypothalamic portion of the third ventricle (see Fig. 7*B* for comparison).

abnormal cells nor protein. Routine skull roentgenograms revealed a possible erosion of the posterior clinoids possibly secondary to increased intracranial pressure. A ventriculogram disclosed a symmetrical enlargement of the ventricular system (Fig. 19).

Her temperature began rising, finally reaching 106.5° F. Several blood cultures were negative. Four weeks after admission she developed signs of bronchopneumonia. One week later she died.

At autopsy there was a confluent bronchopneumonia. Examination of the brain revealed a mild degree of opacity of the meninges. In the right temporal area the white matter looked grayish and brittle. On section the substantia nigra was somewhat small and pale. Histopathological diagnosis: encephalitis.

CASE II. The patient was a twenty-two year old colored woman admitted with a chief complaint of headache, blurred vision and vomiting for four years. The headache had been mainly frontal in location, starting as a dull pain in the morning and becoming sharp in nature later in the day. The headaches had always been associated with vomiting which was not force-

ful. During this time the patient also noted poor vision which was not helped by glasses. Six weeks prior to admission she began losing weight and had lost 20 pounds. She had also noticed vertigo and a staggering gait, as well as frequency and urgency of urination. Her past history revealed successful treatment for syphilis two years before admission.

Physical examination revealed a dark bluish line along the gum margins. The optic discs were blurred along their nasal margins, and there was bilateral optic atrophy. Dullness and exaggerated breath sounds were noted over the upper lobe of the left lung. Neurological examination revealed a hazy memory, an unsteady staggering gait, bilaterally absent Achilles tendon reflexes and hypoactive patellar reflexes. A lumbar puncture revealed a pressure of 325 mm. of water. Examination of the cerebrospinal fluid revealed 6 monocytes, a protein of 46 mg. per 100 cc., and a negative serology. A preoperative ventriculographic study showed a probable mass lesion in the posterior fossa near the midline producing a block of the aqueduct and obliterating the fourth ventricle (Fig. 20). The lateral and third ventricles were considerably dilated. A suboccipital craniectomy revealed a gelatinous cyst in the lower portion of the fourth ventricle. The cerebellar vermis



FIG. 10. Erect anteroposterior projection of the encephalogram of a fourteen year old boy with spells of drowsiness. The third ventricle shadow, *a*, is projected upward between the lateral ventricle shadows.

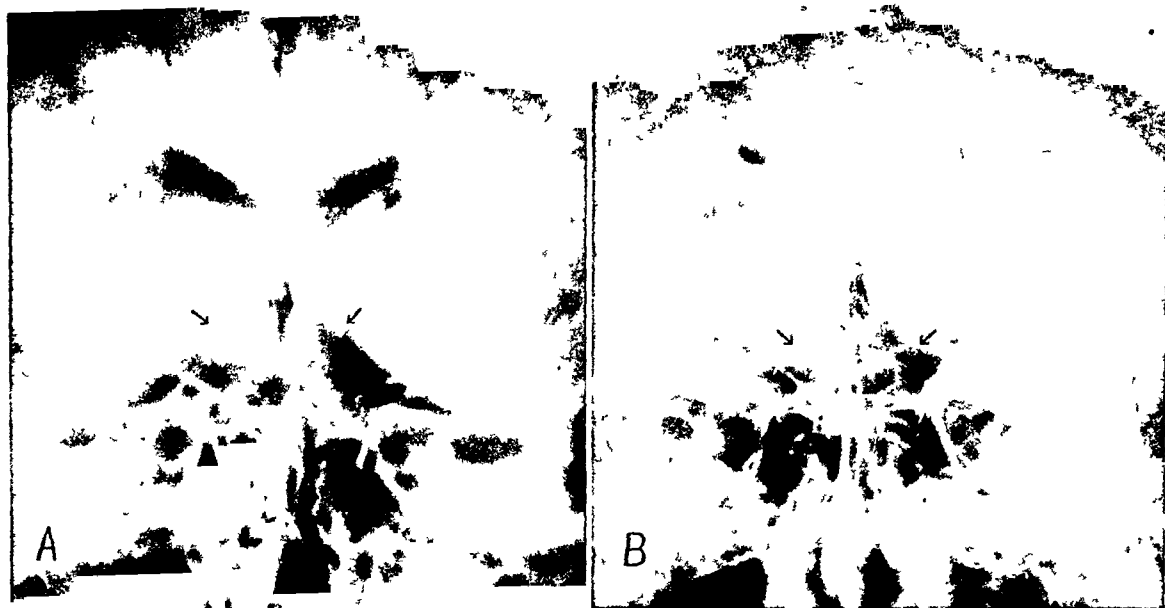


FIG. 11, *A* and *B*. Encephalogram of a seventeen year old boy with epilepsy of three years' duration. The third ventricle is well visualized in both posteroanterior projections. (*A*) was made immediately after the injection of air and (*B*) was made twenty-four hours later. Note the subtentorial air is also visible in both examinations (arrows).

was twice as wide as normal, and the cerebellar tonsils protruded down into the spinal canal. The cystic mass was removed from the vermis and the fourth ventricle and aqueduct were then visualized and it was seen that a mass of yellow tumor tissue was compressing the aqueduct. Only a portion of this tissue could be removed. Histopathological diagnosis: spongioblastoma polare.

Four years later the patient was still alive with residual neurological symptoms consisting of poor vision and occasional headache.

CASE III. The patient was a twelve year old white girl complaining of continuous frontal headache for five months. Her past history revealed she had been backward in school and always somewhat dull mentally. Five months before admission she developed a continuous frontal headache which became progressively worse. Four weeks before admission she had four generalized convulsions lasting fifteen to thirty minutes. During this time she also had pain in the back of the neck for one week.

Physical examination revealed a large symmetrical head. The facies were somewhat senile, there was an increase in hair growth, and a generalized somewhat spotty pigmentation was noted over the trunk. Neurological examination

showed low intelligence, poor orientation, depression, tilting of the head to the left, poor coordination, wide-based gait, asymmetry of the palpebral fissures, the right being greater, and bilateral papilledema of two diopters.

Routine skull roentgenograms revealed evidence of marked increased intracranial pressure. There was a marked convolitional atrophy with widening of the sutures. The dorsum sellae was atrophied and the pituitary fossa was enlarged. The ventriculograms (Fig. 21) revealed uniform enlargement of the lateral ventricles. There was marked distention of the third ventricle. The upper portion of the aqueduct was distended and there appeared to be a block in the lower portion. The fourth ventricle was not visualized. A suboccipital craniectomy the same day revealed a block in the aqueduct of Sylvius, but no tumor could be demonstrated. Twenty-four hours later she developed a hyperthermia and died. An autopsy limited only to the base of the brain revealed a gelatinous tumor enlarging the right inferior colliculus and invading the left colliculus. It had obliterated the aqueduct of Sylvius so that the third ventricle was markedly dilated. Similar gelatinous areas were found in the middle cerebellar peduncle and the wall and floor of the fourth ventricle. In the medulla the left cerebellar peduncle was enlarged to



FIG. 12, *A* and *B*. Ventriculogram of a twenty-nine year old man with a lesion blocking the aqueduct of Sylvius. (*A*) The third ventricle is symmetrically dilated. In the lateral projection (*B*), the posterior commissure, *a*, is quite large. The middle commissure, *b*, is small.

twice its normal size. Histopathological diagnosis: astrocytoma.

CASE IV. This patient was a seven year old girl admitted complaining of headaches for three weeks. A bilateral internal strabismus of the eyes had been present for one year and visual difficulties had been noticed for five months. One week before admission, the patient's headache was accompanied by projectile vomiting, both continuing up to admission. One

week before admission, she had also fallen injuring her head, at which time she lost consciousness for ten minutes.

Physical examination revealed a contusion of the forehead. Sluggishness of the corneal and gag reflexes was noted. The pupillary light reflex and consensual reflexes were absent bilaterally. Bilateral papilledema of four diopters was present. There was evidence of weakness of the left seventh and twelfth cranial nerves and there was bilateral weakness of the third and fourth



FIG. 13, *A* and *B*. The ventriculograms show a third ventricle of an eight year old girl with a glioma obstructing the aqueduct of Sylvius. (*A*) The enlarged third ventricle shadow is round in the posteroanterior projection of Monro, *a*, are markedly enlarged and the middle commissure, *b* is small.



FIG. 14, *A* and *B*. Ventriculograms of a nine year old boy with an obstructing glioma in the posterior fossa. (*A*) The large third ventricle shadow is somewhat diamond shaped. (*B*) In the lateral projection the middle commissure is not visible.

cranial nerves. Bilateral cerebellar signs consisting of generalized hypotonia and dysdiadochokinesia were noted. A bilateral Babinski reflex was also present but the reflexes were generally hypoactive.

On the third day of admission a ventriculographic study (Fig. 22) revealed evidence of a midline lesion in the posterior fossa blocking the

aqueduct and obliterating the fourth ventricle. A suboccipital craniectomy revealed a tumor beneath the cerebellum in the midline and involving the brain stem. Histopathological diagnosis: fibrillary astrocytoma.

Following operation the patient went into shock and developed hyperthermia. On the third postoperative day a brain cannula was



FIG. 15, *A* and *B*. Ventriculograms of a nineteen year old girl with an obstructing lesion in the midbrain. (*A*) The third ventricle shadow is hexagonal and widest in the region of the hypothalamic sulci (arrows). The superior angles, *a*, are in the region of the transverse fissure of the cerebrum. (*B*) The middle commissure is not definitely visualized. Note that there is very little anterior ballooning.



FIG. 16, *A* and *B*. Third ventricle of a five year old boy with recurrent meningitis and obstructive internal hydrocephalus. (*A*) The third ventricle shadow is triangular in outline. The linear shadow (arrows) is an emissary vein in the frontal bone. (*B*) In the lateral projection the anterior one-half of the third ventricle shadow does not appear dilated. The foramina of Monro are markedly dilated. The middle commissure is not visible.

inserted but the patient became progressively worse and finally died.

CASE V. The patient was a twenty-nine year old white housewife complaining of head pains, vomiting, and "attacks" for four years. Past history revealed kidney trouble at nine years of age and an ovarian cyst removed seven months previous to admission. Four years before admission, and one month after spontaneous delivery of her only child, she suddenly began to have spells of nausea and vomiting several times daily. These were accompanied by numerous generalized convulsive attacks initiated by sharp pain over the eyes and vertex of the head. No loss of bladder or bowel control and no loss of consciousness. These attacks continued for two weeks and were followed by a constant dull headache with occasional sharp pains over the eyes which persisted. She was given sedation and suffered only three additional attacks two of which were just previous to admission.

Physical examination revealed one diopter papilledema of both optic discs. There were no other significant findings. Routine laboratory studies revealed nothing significant. Routine skull roentgenograms showed enlargement of the sella turcica and erosion of the dorsum sellae indicative of an intracranial lesion. In pre-operative ventriculograms (Fig. 23) the lateral

and third ventricles were markedly dilated. The aqueduct and fourth ventricle were not visualized and the patient was believed to have a block in the aqueduct of Sylvius. Suboccipital craniectomy eight days after admission revealed an inoperable tumor close to the aqueduct and near the tentorium.

Autopsy limited to the head (significant findings only) revealed the convolutions were flattened and the sulci narrowed. Between the pons and infundibulum there was a 2 by 1.5 by 1 cm. thin-walled cystic mass (probably third ventricle) which appeared to project from the region of the interpeduncular fossa. The mass was ruptured, and thin slightly bloody fluid escaped, the amount of which was greater than that which a cavity of the above dimensions could hold. Incision of the body of the corpus callosum uncovered a curious soft mass in the region of the pineal. In the quadrigeminal plate there was an infiltrative mass. The third ventricle was markedly dilated (Fig. 24). Histopathological diagnosis: spongioblastoma polare.

CASE VI. This was the first admission to the neurosurgical service of a thirty-two year old Polish woman complaining of frontal headaches for seven to ten years. The headaches were accompanied by numbness around the mouth

Transitory blurring of vision and spots in front of the eyes had been present for seven to ten years.

Physical examination disclosed only a possible hyperesthesia of the right ophthalmic division of the fifth cranial nerve, generally hyperactive reflexes, and mental apathy. Skull roentgenograms showed evidence of longstanding increased intracranial pressure in the calvarium and erosion of the dorsum sellae. Encephalograms (Fig. 25) on another service had revealed a large collection of air beneath the tentorium but the ventricular system was not visualized. A ventriculographic study on the third day of admission revealed the lateral and third ventricles to be greatly dilated. The fourth ventricle was not visible (Fig. 26). On the eighth day of admission a suboccipital craniectomy and splitting of the cerebellum disclosed no tumor. She was referred to a State Hospital one year later because of inability to care for herself.

Comment. Herniation of the posterior wall of the third ventricle occurs when there is obstruction of the cerebrospinal pathway in the aqueduct or fourth ventricle. The herniation may develop in the region of the suprapineal recess or below the pineal just above the posterior com-

missure. In larger herniations it appears that most of the entire posterior wall has herniated (Fig. 19, 22, 23 and 26). Occasionally dilatation of the suprapineal recess occurs in hydrocephalus secondary to meningo-encephalitis (Fig. 19). One would not expect a typical large herniation of the third ventricle in instances where the symptoms are of short duration and there is no intrinsic block in the aqueduct or fourth ventricle. In cases in which the fourth ventricle and aqueduct are not visualized, Pennybacker and Russell⁶ have regarded enlargement of the suprapineal recess as evidence of an intrinsic lesion of the brain stem (benign stricture or tumor) as opposed to an extrinsic lesion such as a tumor of the superior vermis or pineal gland. Case 1 of our series is an exception to that observation.

As the herniation of the third ventricle progresses it extends beneath the splenium of the corpus callosum, through the incisura of the tentorium and into the cisterna ambiens above the corpora quadrigemina. Case 11 (Fig. 20) is a twenty-two year old colored woman with a glioma involving the cerebellar vermis and aqueduct of Sylvius.



FIG. 17, *A* and *B*. Ventriculograms of a forty-eight year old man with a cerebellar tumor obstructing the aqueduct of Sylvius. (*A*) The third ventricle is pentagonal in outline. The lower anterior portion of the septum pellucidum, *a*, is superimposed upon the third ventricle shadow. (*B*) In the lateral view the middle commissure is not visible.



FIG. 18, *A* and *B*. Ventriculograms of a six year old boy with recurrent pneumococcic meningitis. In the postero-anterior projection (*A*), the third ventricle shadow has the shape of an inverted bottle or flask. It is apparent in the lateral projection (*B*) that the lower or "neck" portion of the shadow represents the anterior hypothalamic part of the third ventricle.

In this instance the enlarged suprapineal recess has extended posteriorly for some distance but has not as yet ballooned out to any extent. Case III (Fig. 21) illustrates an early but somewhat larger herniation of the third ventricle secondary to an astrocytoma blocking the lower portion of the aqueduct of Sylvius. Herniations of the third and lateral ventricles are less likely to develop if the posterior fossa is filled with a bulky tumor or a dilated fourth ventricle and aqueduct. In Case III the herniation has not descended beneath the tentorium because of the intervening extensive tumor and the dilated rostral portion of the aqueduct. Instead it has pushed upward outlining the splenium of the corpus callosum (Fig. 21). If there is no intervening mass the third ventricle continues to balloon out posteriorly and downward as in Case IV (Fig. 22).

The herniations of the third ventricle discussed by Childe and McNaughton¹ were in no instance as large as those from the lateral ventricles. Cases v and vi are examples of third ventricle herniations which approach the size of most of the reported herniations of the lateral ventricles (Fig. 23, 25 and 26). This is to be expected since both types of herniation occupy al-

most exactly the same area in the midline between the splenium, occipital lobes and tentorium above, and the corpora quadrigemina and cerebellum below (Fig. 1). It is interesting to note that in the fully developed herniations the third ventricle tends to have a square contour in the anteroposterior projection, the upper border being formed by the apex of the tentorium and the lower by the brain stem (Fig. 23 and 26). The "square sign" is best shown in Case v (Fig. 23). It is also present in Dyke's third case which he reported as a herniation of the lateral ventricle (not proved). In Case v the long standing symptoms of increased intracranial pressure were secondary to a small diffuse astrocytoma in the lamina quadrigemina. Although there is a pressure defect along the anterosuperior margin of the cerebellum (Fig. 24), the patient exhibited no definite signs nor symptoms of a cerebellar lesion. If one examines the brow down position of the ventriculogram closely (Fig. 23), dark shadows can be seen in the region of the floor of both lateral ventricles. This was at first thought to be "dimpling" or early herniation of the lateral ventricles which had not become "full blown" because of the intervening herniation of the third ventri-



FIG. 19, *A* and *B*. Case I. A thirty-one year old woman with meningoencephalitis and secondary hydrocephalus. Note the dilated suprapineal recess, *a*, which can be seen in the posteroanterior projection as well as in the lateral.

cle. However, examination of the preserved autopsy specimen revealed thinning of the crura of the fornix but no definite dimpling or herniation. The shadows therefore probably represent lateral and upward extension of the third ventricle herniation beneath crura of the fornix in the region of the hippocampal fissures.

Case VI is another example of third ven-

tricle herniation but unique in that the initial air study demonstrated only the herniation.

LATERAL AND FOURTH VENTRICLE HERNIATIONS

Penfield⁵ in 1929 first called attention to the area in which we are now interested when he reported a case that was found to



FIG. 20, *A* and *B*. Case II. Ventriculograms of a twenty-two year old colored woman with a posterior fossa glioma. (*A*) In the lateral projection the lateral and third ventricles are markedly enlarged and the suprapineal recess (arrows) has herniated posteriorly. The proximal portion of the aqueduct of Sylvius, *a*, is dilated and displaced anteriorly by the tumor which has obstructed the lower end of the aqueduct. The infundibular recess, *b*, is dilated and projects into the sella turcica. The middle commissure is not visible. (*B*) The third ventricle is markedly enlarged in all diameters of the posteroanterior projection.

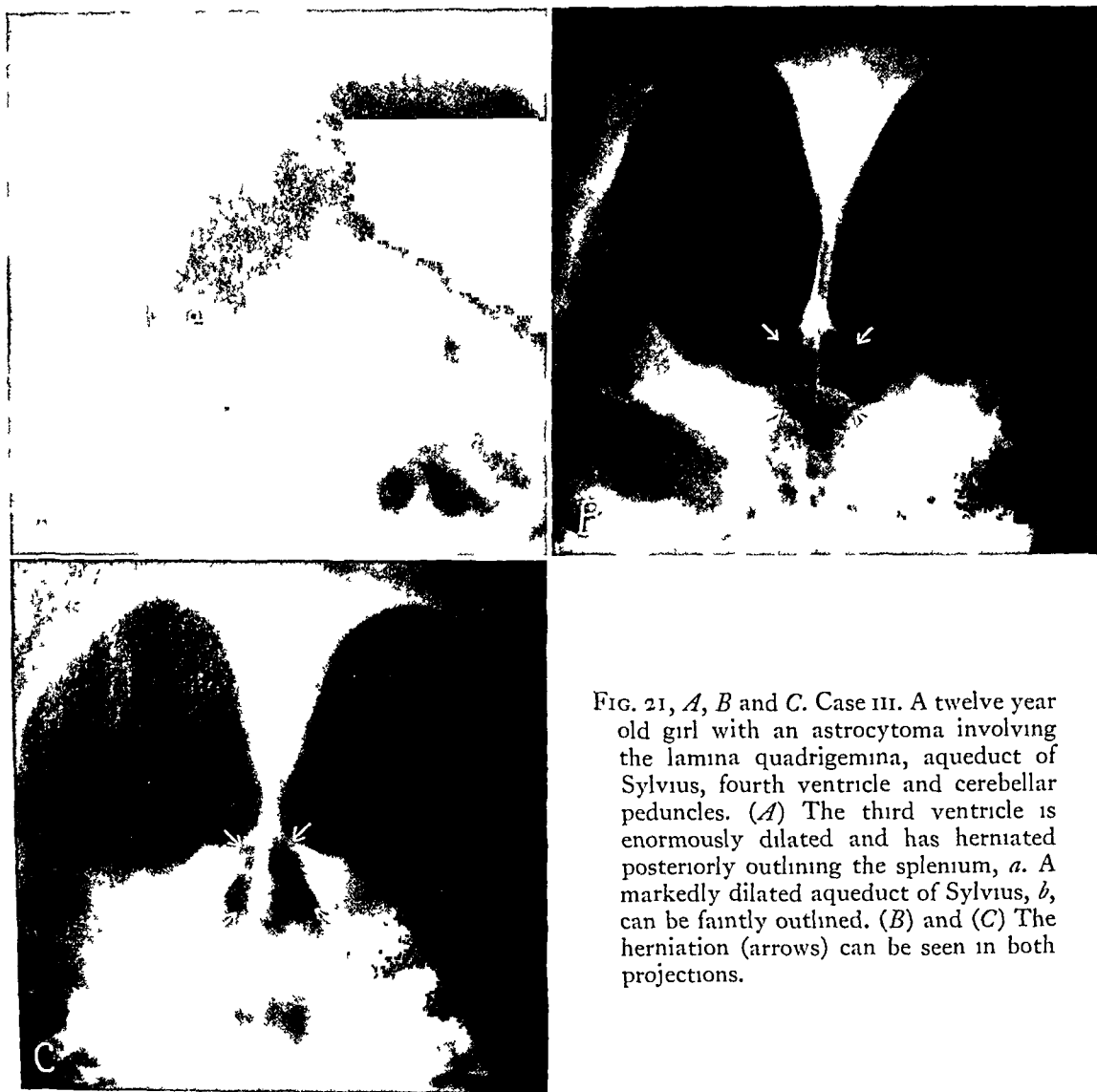


FIG. 21, *A*, *B* and *C*. Case III. A twelve year old girl with an astrocytoma involving the lamina quadrigemina, aqueduct of Sylvius, fourth ventricle and cerebellar peduncles. (*A*) The third ventricle is enormously dilated and has herniated posteriorly outlining the splenium, *a*. A markedly dilated aqueduct of Sylvius, *b*, can be faintly outlined. (*B*) and (*C*) The herniation (arrows) can be seen in both projections.

have a cystic cavity overlying the midbrain. The cyst communicated with both lateral ventricles through a defect in the tela chorioidea below the splenium of the corpus callosum.

In 1940 Sweet⁸ reported a case which he termed "ventriculostium." In this case there was a herniation in the posteromedial portion of the floor of the right lateral ventricle just anterior to the tip of the splenium of the corpus callosum and above the right crus of the fornix. The rostral portion of the aqueduct of Sylvius had been occluded by a small tumor and the herniated portion of the lateral ventricle had extended

through the incisura of the tentorium where it "was in effect a large, fluid tumor in the upper part of the posterior fossa" which did not communicate with the subarachnoid space. The same year Noetzel³ reported 3 cases of arachnoid cysts in the cisterna ambiens. One was non-communicating while the others communicated with a lateral ventricle. Dyke² subsequently described 3 cases of acquired subtentorial pressure diverticulum of the cerebral lateral ventricle but did not mention herniation of the third ventricle as a possibility in his unverified cases nor in his differential diagnosis.

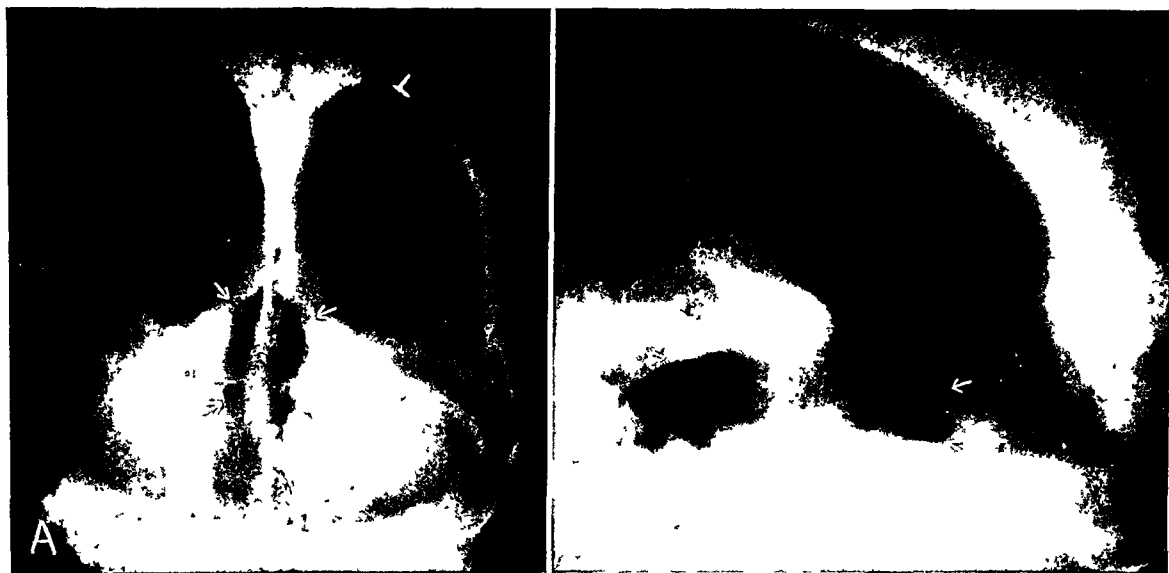


FIG. 22, *A* and *B*. Case IV. Posterior herniation of the third ventricle in a seven year old girl with a fibrillary astrocytoma involving the brain stem. (*A*) The herniation (arrows) is as yet not fully developed and the "square sign" is not present in the anteroposterior projections. Note the thin middle commissure, *a*. (*B*) In the lateral projection the herniation can be seen extending posteriorly and slightly downward (arrows).

CASE VII. The patient is a twenty year old male complaining of throbbing pain over his eyes of three months' duration. The pain suddenly developed while he was at work and was partially relieved by lowering his head or lying down. At the same time he had noticed a blurring of vision and dizziness, with a tendency to fall to the right. Soon after this, vomiting occurred after meals and was frequently accompanied by epistaxis. Six weeks before admission, increasing drowsiness was noted followed by difficulty in controlling the bladder. Tinnitus had been present in the right ear for several days.

Physical examination revealed loss of the physiological cup in both optic discs, slight somnolence, disorientation, inability to stand, muscular incoordination of both arms with tremor and past pointing most marked on the left, loss of position sense in both feet, and generalized muscular weakness.

Special studies revealed a slight bilateral concentric constriction of the visual fields with a right lower quadrant cut in both eyes. Routine skull roentgenograms revealed evidence of increased intracranial pressure. Preoperative ventriculograms (Fig. 27) showed marked dilatation of the lateral ventricles secondary to a mass filling the third ventricle. At operation what was believed to be a tumor in the third ventricle was visualized but not adequately

exposed. The patient was discharged improved but died one month later at home.

CASE VIII. The patient was a twenty-six year old white male admitted to the hospital complaining of spells of severe frontal headache for seven weeks. The headaches had been throbbing in nature and had been accompanied by forceful vomiting for six weeks. Generalized weakness had been noted for four weeks and diplopia and blurred vision for two weeks.

Positive findings upon physical examination were essentially only those of the neurological. There was some unsteadiness in walking, a mild tremor of the hands, a slight dysdiadochokinesia, four diopters of papilledema bilaterally, right cranial sixth nerve paralysis, transient ankle and patellar clonus, and hyper-reflexia except for an absent right biceps tendon reflex. Routine skull roentgenograms revealed evidence of increased intracranial pressure, and a preoperative ventriculographic study (Fig. 28) revealed a mass lesion in the midline producing partial occlusion of the foramina of Monro and filling the third ventricle, at least in its anterior portion. Both lateral ventricles were markedly dilated, the right more than the left and the septum pellucidum was shifted toward the left side. The patient was provided with a right frontoparietal decompression, but continued to show signs of increased intracranial

pressure and died of pulmonary edema on the fifth postoperative day. Postmortem examination revealed a tumor in the third ventricle extending into the right basal ganglia and thalamus. Histopathologically, it was found to be a subependymal fibrillary astrocytoma.

CASE IX. The patient was a nineteen year old girl admitted in a semi-comatose condition. Four and one-half months before admission she had an episode of headache, vomiting, and drowsiness lasting three weeks. One week before admission she suffered a similar attack fol-

lowed by generalized convulsions two days before admission.

Physical examination revealed bilateral papilledema of two to three diopters. She was unable to sit up or stand, but otherwise she was essentially negative neurologically.

Visual field examination revealed a right homonymous hemianopsia. Routine roentgenograms showed evidence of increased intracranial pressure. Preoperative ventriculograms (Fig. 29) showed marked dilatation of both lateral ventricles with lack of visualization of the third

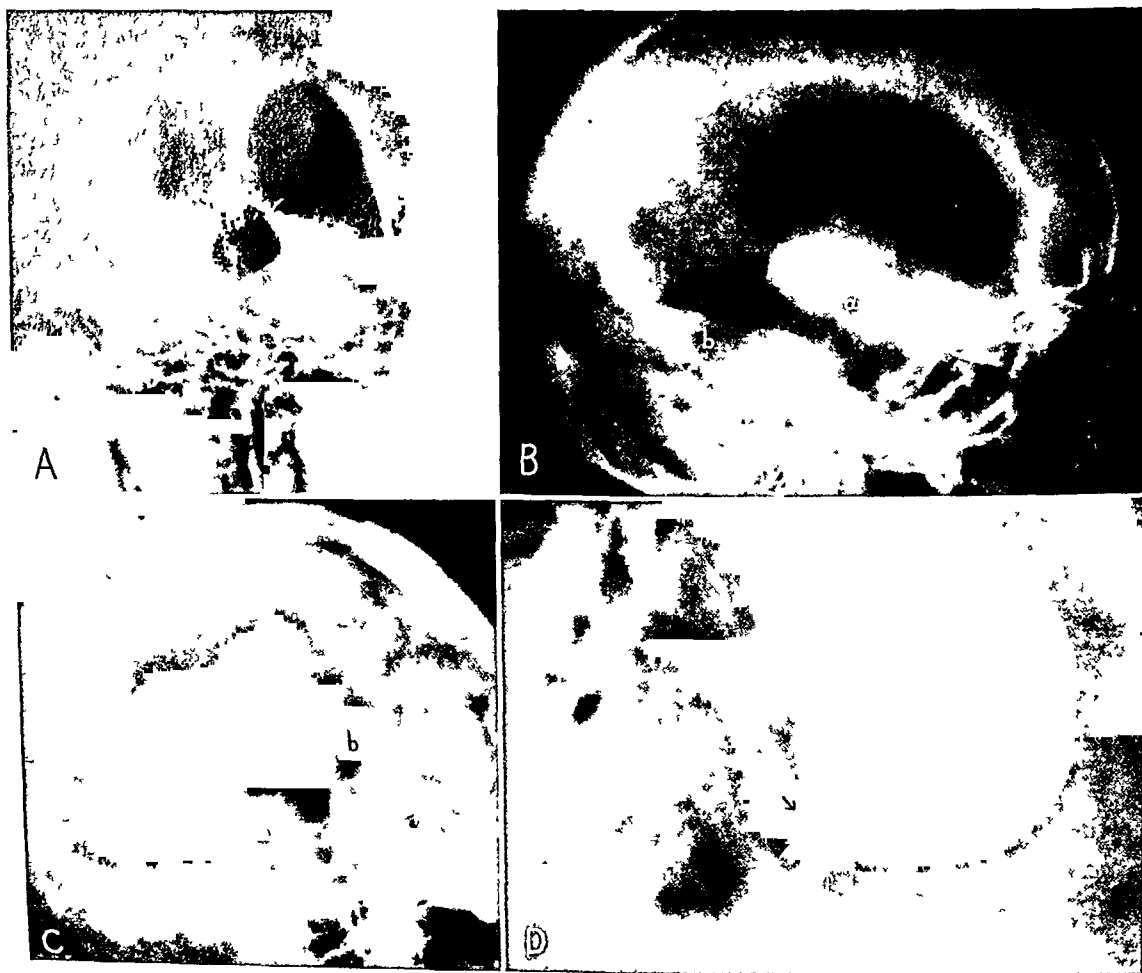


FIG. 23, *A B, C* and *D*. Case v. Posterior herniation of the third ventricle in a twenty-nine year old woman with a small glioma infiltrating the lamina quadrigemina and blocking the aqueduct of Sylvius. (*A*) Note the square outline (arrows) of the herniation, i.e., the "square sign," which can be seen in the anteroposterior projection. In the lateral (*B*) and brow-down (*C*) projections the herniation, *b*, can be seen extending below the inferior and posterior horns of the lateral ventricles. The continuity of the herniation with the third ventricle, *a*, is readily demonstrable ruling out the possibility of a herniation of a lateral ventricle. Lateral and upward extensions of the posterior wall are also present and are best visualized in the brow-up position (*D*) (arrows).



FIG. 24. Sagittal section of the brain of Case v showing, *a*, the thin transparent posterior wall of the collapsed herniation of the third ventricle. Note the pressure defect along the superior border of the cerebellum.

ventricle probably secondary to a third ventricle tumor. A right frontal craniotomy revealed a midline tumor involving the foramina of Monro, filling the third ventricle, and extending into the adjacent brain tissue. The patient died twenty-four hours after operation. Post-mortem examination of the brain revealed operative trauma in the right frontal lobe adja-

cent to the corpus callosum and region of the third ventricle. The walls of the anterior portion of the third ventricle were covered with tumor tissue which extended into the corpus striatum and internal capsule on the right. Posteriorly the third ventricle was well delineated and appeared to be normal in size. A massive hemorrhage was present in the hypothalamic area

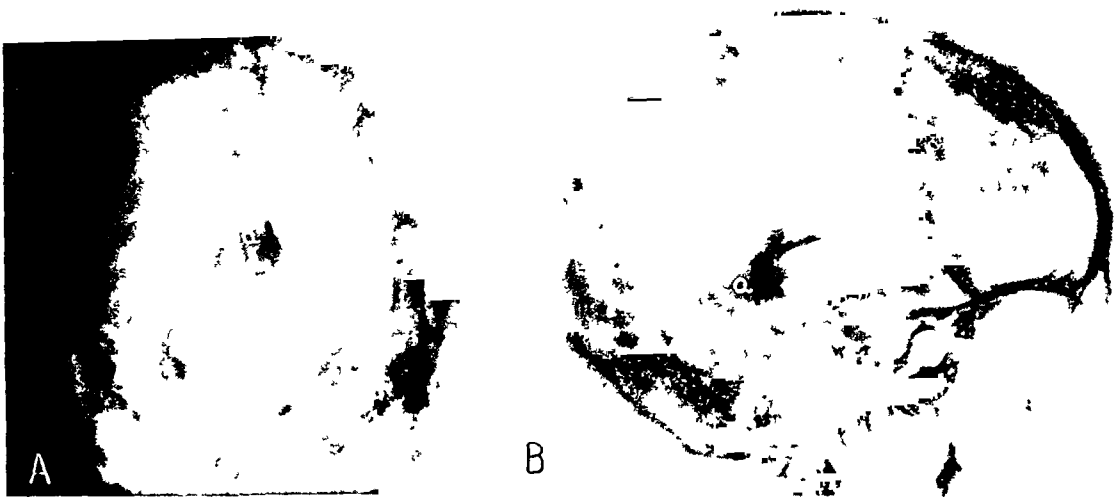


FIG. 25, *A* and *B*. Case vi. Encephalograms of a thirty-two year old woman with obstructive hydrocephalus. The ventricular system is not filled but there is a collection of air, *a*, visible in both projections, which represents a herniation of the third ventricle.

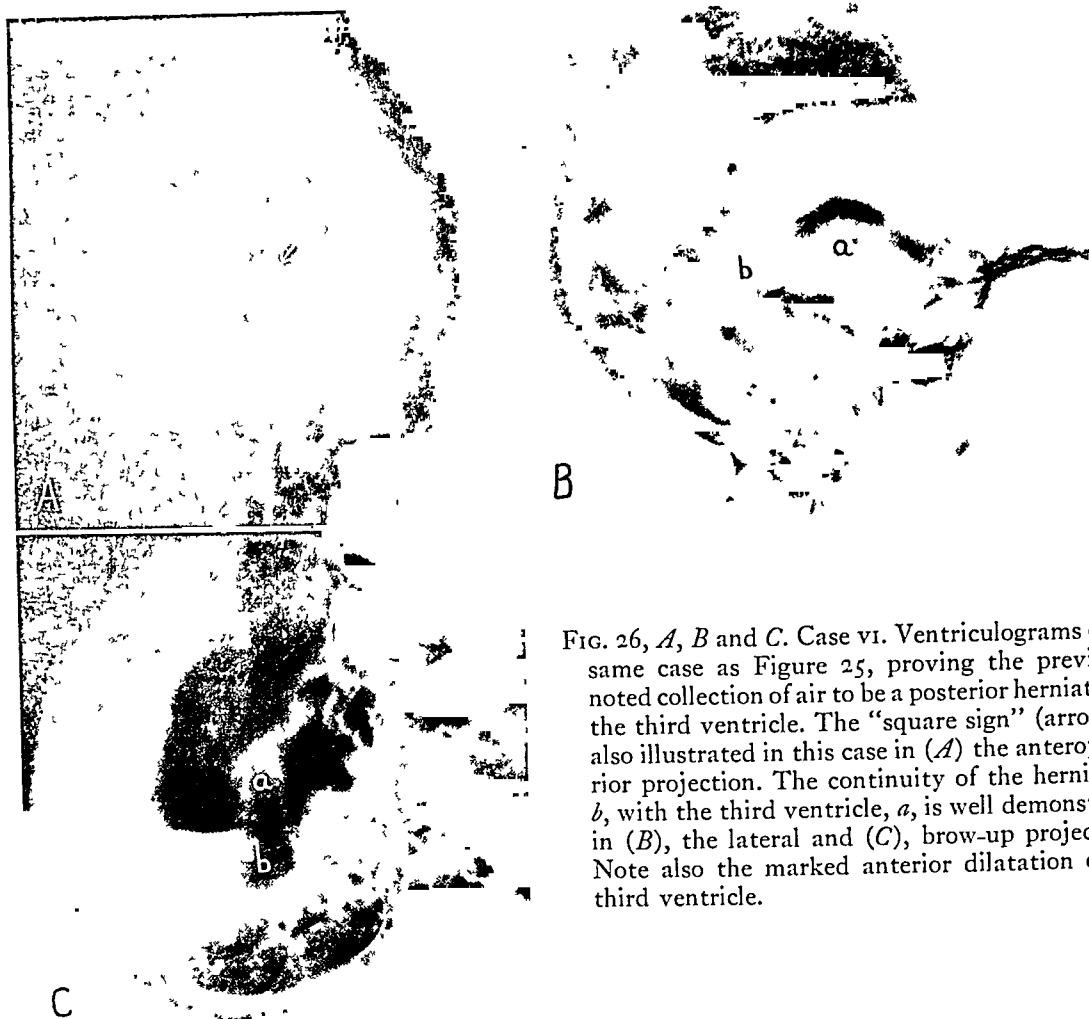


FIG. 26, *A*, *B* and *C*. Case VI. Ventriculograms of the same case as Figure 25, proving the previously noted collection of air to be a posterior herniation of the third ventricle. The "square sign" (arrows) is also illustrated in this case in (*A*) the anteroposterior projection. The continuity of the herniation, *b*, with the third ventricle, *a*, is well demonstrated in (*B*), the lateral and (*C*), brow-up projections. Note also the marked anterior dilatation of the third ventricle.

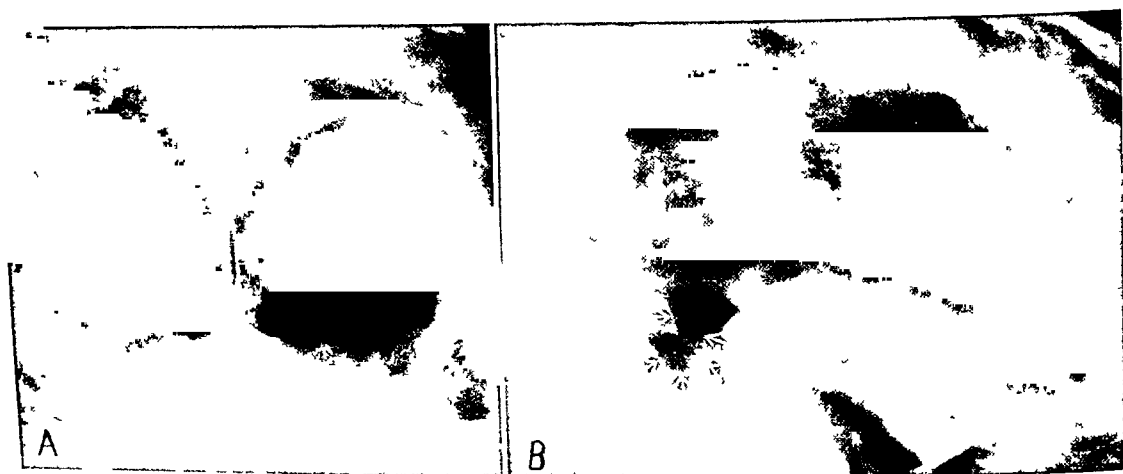


FIG. 27, *A* and *B*. Case VII. A twenty year old male with an obstructive hydrocephalus secondary to a tumor in the third ventricle. There is "dimpling" or bilateral early herniation of both lateral ventricles (arrows) which is seen best in (*B*), the lateral projection.

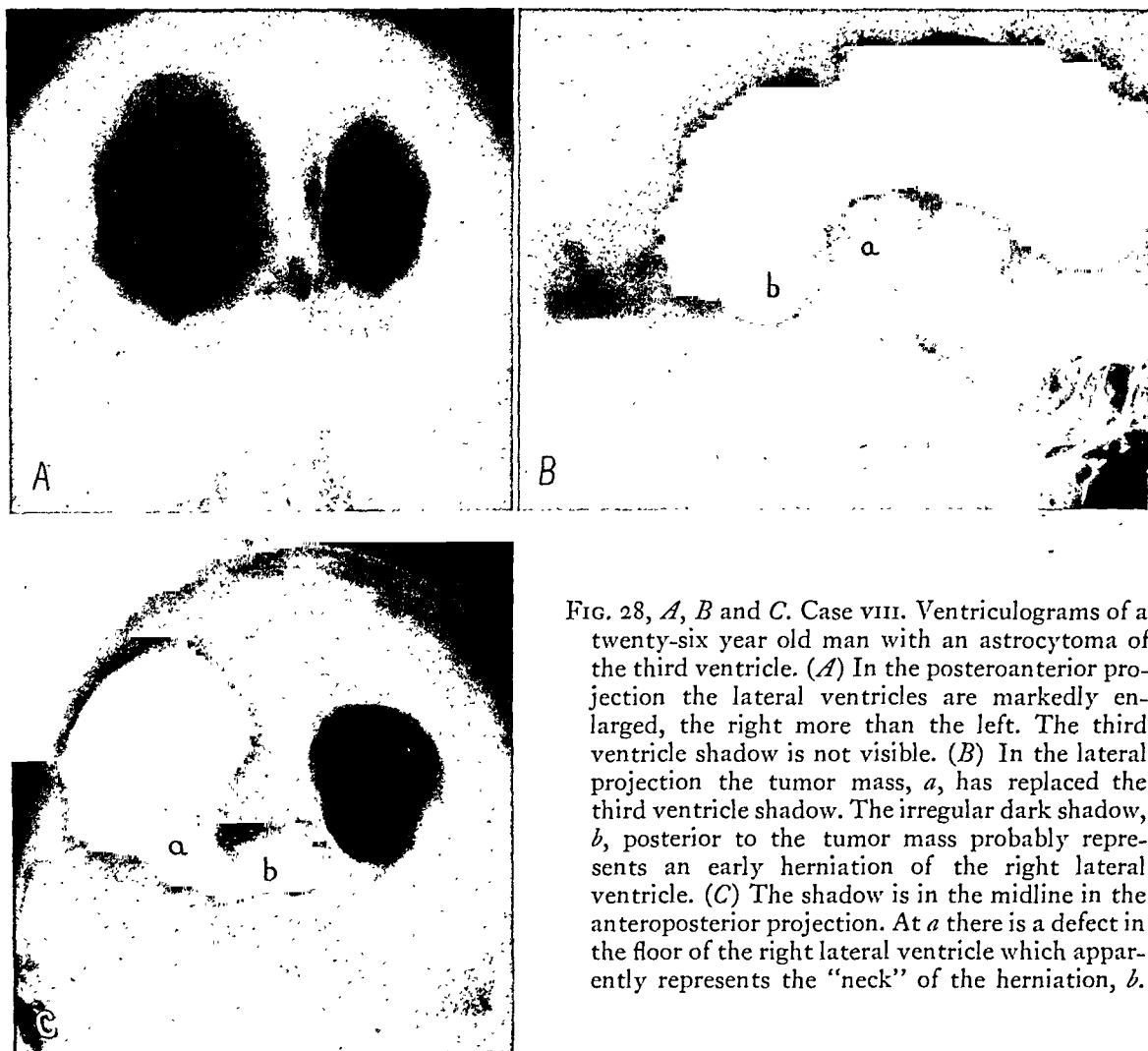


FIG. 28, *A*, *B* and *C*. Case VIII. Ventriculograms of a twenty-six year old man with an astrocytoma of the third ventricle. (*A*) In the posteroanterior projection the lateral ventricles are markedly enlarged, the right more than the left. The third ventricle shadow is not visible. (*B*) In the lateral projection the tumor mass, *a*, has replaced the third ventricle shadow. The irregular dark shadow, *b*, posterior to the tumor mass probably represents an early herniation of the right lateral ventricle. (*C*) The shadow is in the midline in the anteroposterior projection. At *a* there is a defect in the floor of the right lateral ventricle which apparently represents the "neck" of the herniation, *b*.

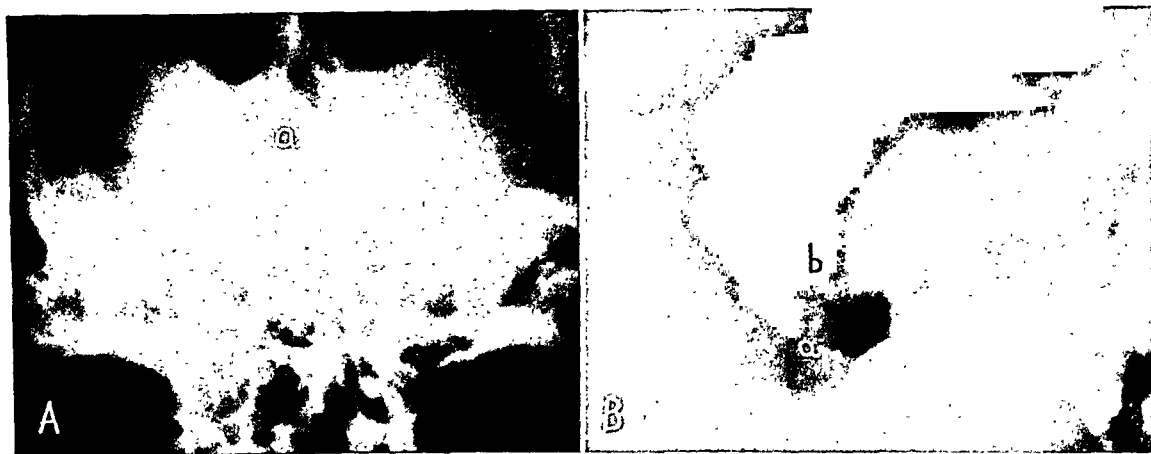


FIG. 29. *A* and *B*. Case IX. Herniation of the lateral ventricle in a nineteen year old girl with a glioma involving the anterior portion of the third ventricle. In (*A*), the anteroposterior projection, the herniation can be seen at *a*. In (*B*), the lateral projection, the herniation, *a*, can be seen. Its rather wide communication with the lateral ventricle is visible at *b*.

extending back to the mesencephalon (Fig. 30). Histopathological diagnosis: spongioblastoma polare.

CASE X. The patient is a thirty-two year old white male complaining of generalized headaches for fifteen months with fogging of vision and diplopia. A staggering gait had been present for twelve months and weakness of the legs, ten months. Two months before admission the patient noted clonic contractions of the right arm and the right leg several times a week.

Physical examination revealed impaired vi-

tricle herniations, it was apparent that since herniations of the third and lateral ventricles occupy the same potential space, one type would tend to prevent the other. Because of the larger areas of thinness in the posterior wall of the dilated third ventricle, it seemed likely that herniations of the third ventricle would occur most often in small obstructive posterior fossa lesions. Furthermore, herniations of the lateral ventricle would be most likely to occur secondary to obstructive lesions in the



FIG. 30. Coronal section through brain of Case IX just anterior to the "dimpled" origin (arrows) of the lateral ventricle herniation.

sion, six diopters of papilledema in each eye, sluggish pupillary reflexes, bilateral horizontal and vertical nystagmus, and an ataxic gait.

On the fourth day of admission, a ventriculogram (Fig. 32) revealed a diffuse dilatation of the entire ventricular system suggesting a posterior fossa lesion, either tumor or arachnoiditis. A suboccipital craniectomy revealed an infiltrating mass or granuloma in the floor and body of the fourth ventricle. Histopathological diagnosis: fibrillary astrocytoma.

Following the operation, the patient developed pneumonia but recovered and was discharged five days after admission.

Comment. After study of the third ven-

terior portion of the third ventricle or foramina of Monro. Case VII (Fig. 27) is an example of beginning herniation or "dimpling" of the floor of the lateral ventricles which are markedly dilated secondary to a block of the cerebrospinal fluid pathway in the third ventricle. Case VIII (Fig. 28) represents what we believe to be an early herniation of the lateral ventricle in a patient with an astrocytoma involving the third ventricle and right basal ganglia. It is evident that the herniation and dimpling of the floor of the lateral ventricle will occur at the weakest spot. Thinning

out of the crura of the fornix close to their attachment to the under surface of the corpus callosum has been previously noted in marked internal hydrocephalus.¹ As the lateral ventricle enlarges medially the crura of the fornix extend beyond the edge of the tentorium thereby losing its support. This causes the crura to be stretched over the underlying corpora quadrigemina in the incisural opening. Therefore, when there is prolonged increased pressure within the ventricle this area of thinned fornix tends

complete blockage of the cerebrospinal fluid flow in the anterior portion of the third ventricle. The tumor did not extend posteriorly and therefore created an "ideal situation" for the formation of a herniation of the lateral ventricle, i.e., a block in the anterior portion of the third ventricle with no extension of the mass posteriorly to mechanically interfere with or block the herniation near the posterior wall of the third ventricle.

The striking similarity between hernia-



Fig. 31. Coronal section immediately posterior to origin of herniation showing the "neck" of the herniation.

to protrude downwards as shown in Case VIII (Fig. 27). If there has not been a previous herniation of the third ventricle through the incisura of the tentorium beneath the weak point of the crura of the fornix and if there is no large mass lesion in this region a large herniation of the lateral ventricle may develop. Such a large herniation or "subtentorial pressure diverticulum"² was found in Case IX (Fig. 29) during review of the roentgenograms. Examination of the preserved brain specimen confirmed this impression (Fig. 30 and 31). The internal hydrocephalus in this case was secondary to a tumor causing

tions of the third and lateral ventricles is evident. When the radiologist is not certain whether he is dealing with a block in the posterior third ventricle or the aqueduct of Sylvius, the differentiation between third and lateral ventricle herniations becomes exceedingly important for posterior herniation of the third ventricle will not occur when the block is within the third ventricle. Herniation of the third ventricle can usually be differentiated by demonstration of continuity with the body of the third ventricle, obtaining body section roentgenograms if necessary. In most instances herniations of the third and lat-

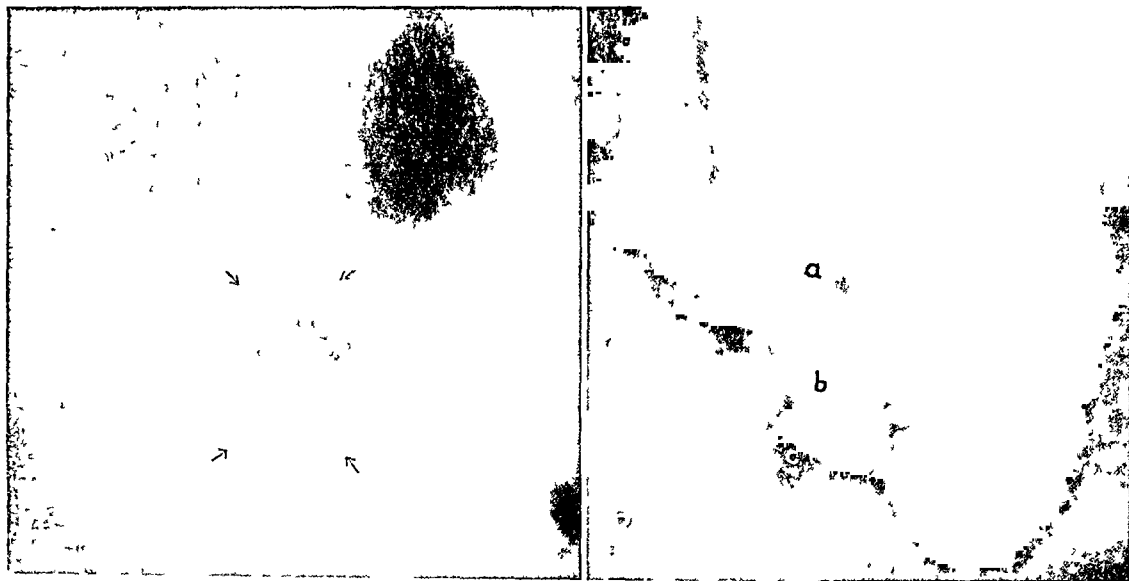


FIG 32, *A* and *B*. Case x. Ventriculograms of a thirty-two year old man with a fibrillary astrocytoma in the fourth ventricle. (*A*) The fourth ventricle (arrows) is markedly enlarged. There is no evidence of a "square sign" (*B*) In the lateral projection it somewhat simulates the appearance of the herniations of the third and lateral ventricles but the fourth ventricle, *c*, and its relation to the aqueduct, *b*, and third ventricle, *a*, are readily demonstrable.

eral ventricles are confused with a dilated fourth ventricle.¹ If, as in one of our patients (Case x) with an astrocytoma blocking the lower end of the fourth ventricle, the fourth ventricle has dilated to the extent of herniating upward through the incisura tentorium (Fig. 32), it may somewhat simulate the appearance of the herniated third or lateral ventricles. Needless to say, the differentiation is important for if the herniation is interpreted as a large fourth ventricle, an erroneous diagnosis of arachnoiditis or tumor in the posterior fossa may be made when the lesion causing the misinterpreted herniation is in reality above the fourth ventricle in the region of the aqueduct or third ventricle. However, in cases of fourth ventricle dilatation and herniation, unless there has been incomplete filling of the ventricular system, the relation of the fourth ventricle to the aqueduct can be demonstrated and the "square sign" will not be seen in the anteroposterior projection (Fig. 32). Herniations may also be confused with arachnoid cysts, cystic tumors and porencephaly² at operation but are less likely to be misin-

terpreted as such in ventriculographic examinations.

Do these posterior herniations produce symptoms as do the anterior herniations of the third ventricle? What is the significance of these herniations from the therapeutic standpoint? It is not within our province to discuss this in detail. Childe and McNaughton¹ believe herniations or diverticula of the ventricles do not produce symptoms because of their slow development. However, there was a large pressure defect in the cerebellum and flattening of the lamina quadrigemina in their case. Sweet⁸ believed the herniation produced symptoms, acting as a large fluid tumor in the upper posterior fossa. His case had a pressure defect in the anterior portion of the cerebellum similar to that in our Case v (Fig. 24). Pennybacker and Russell⁶ believed the herniations probably added to the already existent obstruction of the cerebrospinal fluid by embarrassing the return flow from the posterior fossa to the supratentorial compartment. In one of Dyke's cases the fourth ventricle was compressed and displaced ventrally by the

herniation. Although Case v had a cerebellar defect, there were no detectable signs nor symptoms that could be specifically related to this. Case vi was unable to sit up or stand but there were no signs which could be localized to the area of herniation. Nevertheless, it seems possible, as the majority of authors indicate, that these herniations may be a contributing factor in the production of symptoms. Furthermore, it appears that these large herniations of the third and lateral ventricles may have therapeutic significance in that excision may not only relieve any local pressure symptoms but may offer an opportunity for palliative short circuiting of the cerebrospinal flow around the block in the third ventricle or posterior fossa.¹

SUMMARY

1. Five cases of posterior herniation of the third ventricle, two cases of herniation of the lateral ventricle and one case of fourth ventricle herniation are presented.

2. The location and mechanism of these herniations and the conditions under which they develop are discussed briefly using cases to illustrate the early stages of the herniations.

3. Posterior herniation of the third ventricle occurs when there is obstruction of the cerebrospinal pathway in the aqueduct of Sylvius or fourth ventricle.

4. Lateral ventricle herniation occurs when there is obstruction of the cerebrospinal pathway in the anterior portion of the third ventricle.

5. Fourth ventricle herniation occurs when there is obstruction of the cerebrospinal pathway in the lower end of the fourth ventricle.

6. The differential diagnosis of lateral, third, and fourth ventricle herniations and other lesions is outlined.

7. Accurate identification of ventricular

herniations is important not only in the localization of the causative obstructing lesion, but may be of added therapeutic significance in the presence of large third and lateral ventricle herniations. Excision of the latter seems to offer an opportunity for palliation of otherwise inoperable obstructing lesions.

The authors wish to express their gratitude to Dr. Francis C. Grant, Professor of Neurosurgery and to Dr. George D. Gammon, Professor of Clinical Neurology at the Hospital of the University of Pennsylvania, whose clinical material enabled us to complete this study.

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REFERENCES

1. CHILDE, A. E., and McNAUGHTON, F. L. Diverticula of lateral ventricles extending into the cerebellar fossa. *Arch. Neurol. & Psychiat.*, 1942, 47, 768-778.
2. DYKE, C. G. Acquired subtentorial pressure diverticulum of cerebral lateral ventricle. *Radiology*, 1942, 39, 167-174.
3. NOETZEL, H. Arachnoidal cysten in der Cisterna ambiens. *Zentralbl. f. Neurochir.*, 1940, 5, 281-294.
4. PANCOAST, H. K., PENDERGRASS, E. P., and SCHAEFFER, J. P. The Head and Neck in Roentgen Diagnosis. Charles C Thomas, Springfield, Illinois, 1940.
5. PENFIELD, W. Diencephalic autonomic epilepsy. *Arch. Neurol. & Psychiat.*, 1929, 22, 358-374.
6. PENNYBACKER, J., and RUSSELL, D. S. Spontaneous ventricular rupture in hydrocephalus, with subtentorial cyst formation. *J. Neurol. & Psychiat.*, 1943, 6, 38-45.
7. RANSON, S. W. The Anatomy of the Nervous System from the Standpoint of Development and Function. W. B. Saunders Co, Philadelphia, 1935.
8. SWEET, W. H. Spontaneous cerebral ventriculostium. *Arch. Neurol. & Psychiat.*, 1940, 44, 532-540.
9. VILLIGER, E. Brain and Spinal Cord. J. B. Lippincott Co., Philadelphia, 1931.
10. WILSON, H. M., and LUTZ, W. G. Lesions of the aqueduct of Sylvius. *Radiology*, 1946, 46, 132-138.



THE DIAGNOSTIC SIGNIFICANCE OF CHANGE IN POSITION OF METALLIC FOREIGN BODIES IN BRAIN ABSCESS*

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HISTORICAL

ROENTGENOLOGICAL examination is an indispensable supplement to other methods of study of head injuries. From the early days of the roentgen era roentgenological examination in gunshot wounds of the head has been widely utilized. Credit is given by Phelps¹⁶ (1897) to Eulenberg⁶ (1896) for the first successful roentgenographical demonstration of a metallic foreign body in the cranial cavity. In this country Meyer¹⁵ (1897) apparently made the first roentgenogram of a metallic fragment in the brain. He noted that the hair was lost over the whole posterior half of the head as a result of the exposure. Borden¹ (1900) recorded experiences with roentgen examination of head injuries in the Spanish-American War. Since these early days of roentgenology many new diagnostic approaches and technical improvements have been introduced which have added to the value of roentgenological study of gunshot wounds of the head. Important advances since World War I are the use of air in the ventricles and the introduction of the Potter-Bucky diaphragm, especially the more recent application of the moving grid for examination of patients in the upright position.

GROSS CHANGES ASSOCIATED WITH THE PENETRATION OF A MISSILE INTO THE BRAIN

The penetration of a missile into the brain is followed in the cases which survive by hemorrhage and traumatic necrosis of greater or lesser degree and later, in many instances, by infection. The importance of hemorrhage at the end of a missile tract was described by Cushing¹ (1918, Case No.

62) and recently this has been re-emphasized by Matson and Wolkin¹⁴ (1946) in an interesting discussion of the treatment of this complication of brain wounds. Haynes^{8,9,10} (1945) has attributed the intracerebral hemorrhage and softening of the brain tissue at the end of a missile tract to an "explosive" action of the stopping of the missile. In many cases reviewed by Haynes extensive old hemorrhage and macerated brain tissue were found upon exploration of the ends of these wound tracts.

Cushing^{3,4,5} (1918, 1927) stressed particularly the importance of removing indriven bone fragments in the treatment of penetrating brain wounds. He emphasized that these, more than indriven metal, were likely to be the source of future infection. After thorough primary debridement and esquillectomy are carried out, however, the presence of a retained metallic fragment should not be discounted.

Many metallic fragments serve as a nidus of infection which results in the development of a brain abscess. Cushing^{3,4} (1918) found many instances in his series of cases in which an abscess developed at the end of a missile tract. All of the projectiles in his series of which cultures were made after operative removal were found to be contaminated with microscopic organisms. Septic complications following the retention of missiles were so frequent that he advised that all metallic foreign bodies be removed, unless the act of removal is likely to increase the damage already done by the penetration.

Webster, Schneider and Lofstrom²⁰ (1946) found that the size and irregularity of the metallic fragment were of significance in regard to the damage produced

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and its ability to carry contaminated material into the brain. Of 33 cases of brain abscess occurring in the early weeks after brain injury, more than one-third were associated with retained metallic fragments in their experience. In a study of the late results of penetrating cranial wounds Maltby¹² (1946) found that about one-fifth of the cases with retained metallic foreign bodies developed an infection. A few cases of delayed brain abscess have been reported years after injury. These reports suggest that a decrease in the incidence of infection associated with the retention of metallic fragments occurs as time elapses.

It is impossible to predict which lodged missiles will become the site of a brain abscess and which will remain quiescent. Furthermore, as Rowe and Turner¹⁷ (1945) have pointed out, the clinical manifestations of the development of a brain abscess following a head wound do not compare with the well-known clinical picture seen in civilian practice. Both the early stages and the course of the disease are atypical and insidious. These authors suggested that the absence of progressive neurological signs may be explained by the fact that the lesion develops in cerebral tissue which has been traumatized. They explained the frequent lack of evidence of intracranial hypertension as due probably to the increased room for expansion provided by the destruction of tissue incident to the wound.

Cairns² (1942) has relied on air contrast study of the ventricular system to find those cases in which an unusual process has occurred about retained missiles. He stated that, whereas formerly the only means of avoiding a delayed abscess with certainty was to remove the foreign body, it is now possible by means of encephalography and ventriculography and without recourse to operation to exclude the likelihood of a delayed abscess with reasonable certainty. He carried out encephalography routinely in each case with a retained intracranial metallic foreign body before the patient was discharged from the hospital.

ROENTGENOLOGICAL DEMONSTRATION OF MOVEMENT OF METALLIC FOREIGN BODIES IN THE BRAIN

A change in the position of a fragment on repeated roentgen examination has been associated with the development of a brain abscess about the fragment and has proved to be of diagnostic value. Some investigators have attributed this movement of foreign bodies to the weight of the metal and the relative softness of brain tissue. The experience of Gamlen and Smith⁷ (1917) gained from the frequent re-examination of patients with retained intracranial projectiles led them to the conclusion that movement of these missiles rarely occurs. Speaking of the movement of bullets in the body in general, Ulrich¹⁸ (1935) asserted that the consensus is that bullets do not wander without being surrounded by an abscess. Certainly large metallic fragments have remained in the brain for years without a shift in position.

Vilvandre and Morgan¹⁹ (1916) described 2 cases of penetrating brain wounds during World War I in which movement of a retained metallic foreign body was demonstrated roentgenologically during a ten day and two week period of study. These authors failed to associate the roentgenological findings with abscess formation. A similar case of unusual interest was described by Jefferson¹¹ (1917). In this instance, a bullet lodged in the cerebellum was found to move in the interval between two roentgenological studies made nineteen days apart. At surgical exploration the missile was found to lie in an abscess cavity. In an analysis of 426 penetrating wounds of the skull encountered during the late campaign in the Mediterranean area Martin and Campbell¹³ (1946) reported that on 5 occasions a retained metallic fragment was observed to have changed position in successive roentgenograms. In all but one instance the projectile was found to lie within an abscess cavity. In the fifth case it was found in a hematoma.

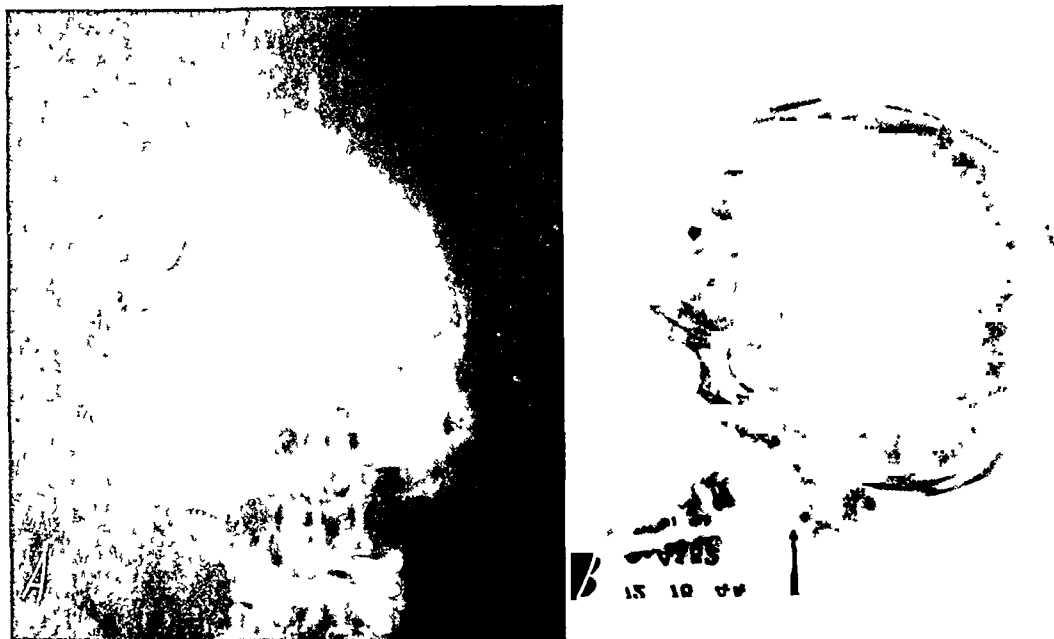


FIG. 1, *A* and *B*. Case 1. Multiple metallic foreign bodies remaining in the right cerebral hemisphere following primary debridement. The roentgenograms were made with the patient in the horizontal position.

MATERIAL

Roentgenological examination of 175 cases of penetrating brain wounds during the first few weeks after injury disclosed that metallic fragments were retained in the brain following primary debridement in 40 instances (23 per cent). In 4 of these

cases (10 per cent) roentgenological study revealed that movement of a metallic fragment occurred. On 2 occasions free gravitational movement of a metallic fragment was shown when the patient was changed from the horizontal to the upright position. In these instances the missile lay

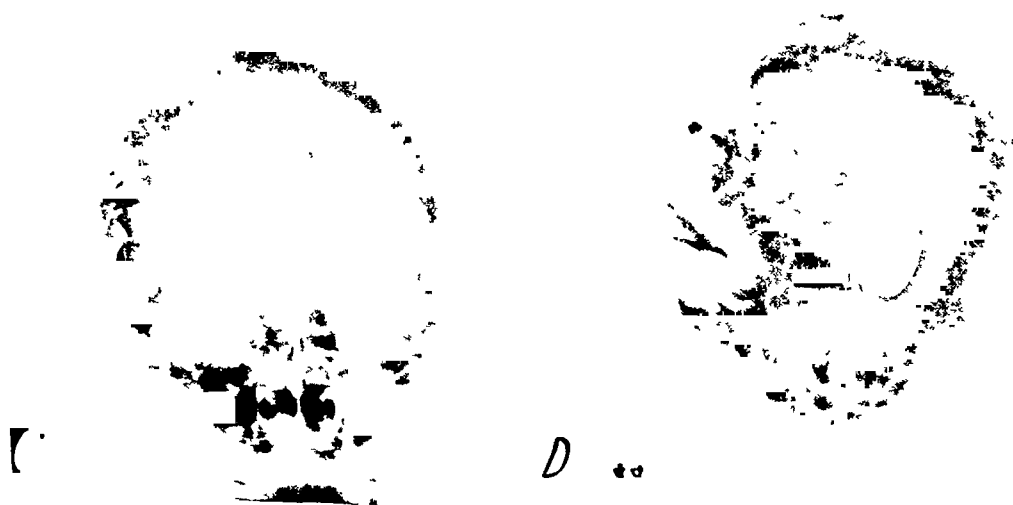


FIG. 1, *C* and *D*. Case 1. Gravitational movement of the intact bullet with the patient placed in the upright position. The bullet was free in an abscess cavity.

free within an abscess cavity. In the other 2 cases free movement was not present, but the position of the foreign bodies changed during the interval between two roentgenological examinations. The shift was due to the development of an abscess with pressure on the adjacent fragment.

CASE I (T. M., No. 4152). This soldier sustained a high explosive shell wound of the right parietal region of the head on November 27, 1944. The following day the wound was debrided and bone fragments were removed from the brain. Removal of the metallic fragments

high explosive shell on November 28, 1944. The metallic fragment entered the skull through the left nasal region and lodged in the left temporal lobe of the brain. Roentgenograms made on December 11, 1944 (Fig. 2, C and D), when compared to those made about two weeks earlier on the day of the injury (Fig. 2, A and B), showed that the metallic fragment had moved downward during the interval. No movement of the fragment was demonstrated when the patient changed position. Surgical exploration was carried out even though the patient exhibited no clinical evidence of an intracranial infection. An encapsulated abscess was found



FIG. 2, A and B. Case II. Metallic fragment lodged in the right temporal lobe of the brain.

was not attempted. Roentgenograms (Fig. 1) made about two and one-half weeks after the injury on December 16, 1944, showed a large number of metallic fragments remaining intracranially. One of these, which had the appearance of an intact bullet, showed gross gravitational movement when the patient was changed from the horizontal to the upright position. When a craniotomy was performed this foreign body was found to lie in an area of the brain which was necrotic. The abscess later ruptured into the right lateral ventricle and the patient died of ventriculitis and meningitis. Bacteriological study showed that the abscess was caused by *Pseudomonas aeruginosa*.

CASE II (O. T., No. 3967). A twenty-six year old soldier was wounded by a fragment of a

in the inferior portion of the left temporal lobe which contained about one ounce of pus from which *Clostridium sporogenes* and a diphtheroid bacillus were cultured. The metallic fragment was in the capsule of the abscess.

CASE III (W. P., No. 5931). The patient was wounded during an artillery barrage by a fragment of a high explosive shell on February 15, 1945. He received an injury of the posterior superior parietal region of the skull and a penetrating wound of the brain. Roentgenograms taken on March 6, 1945, showed a large metallic fragment in the anterior pole of the left frontal lobe of the brain and a cluster of small metallic fragments in the wound tract about half way between the large fragment and the wound of entrance. Some lateral and down-

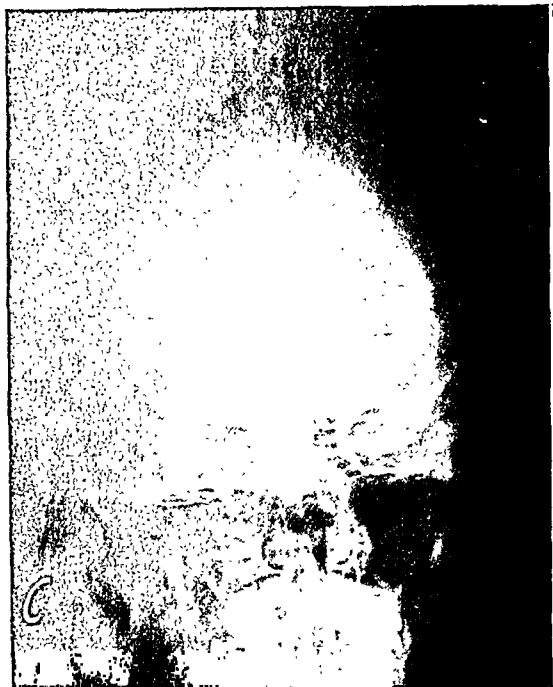


FIG. 2, *C* and *D*. Case II. Downward movement of the fragment during the two-week interval since the examination shown in Figure 2, *A* and *B*. The fragment was in the wall of an abscess and free gravitational movement was not present. There was no clinical evidence of intracranial infection.

ward shift in position of the small cluster of metallic fragments had occurred during the interval since roentgenograms were taken on February 16, 1945. Encephalography was car-

ried out on March 9, 1945. The encephalograms showed a filling defect in the contrast outline of the left lateral ventricle and a shift of the lateral and third ventricles to the right (Fig. 3).



FIG. 3, *A* and *B*. Case III. Encephalograms showing deformity and displacement of the ventricular system by a brain abscess. The abscess formed around a cluster of small metallic fragments in the wound tract half way between the posterior parietal bone defect and the large metallic foreign body lodged in the left frontal lobe of the brain.

Two operations were performed, one for the evacuation of an abscess around the cluster of small metallic fragments, and the other for removal of necrotic material along the original wound tract. The patient subsequently succumbed of ventriculitis and meningitis. A culture of *Pseudomonas aeruginosa* was grown from surgical and autopsy specimens.

CASE IV (E. B., No. 6828). This soldier sustained a penetrating head wound during the latter part of the campaign in Germany. A high explosive shell fragment entered the brain through the left lateral portion of the frontal bone of the skull and lodged in the right frontal lobe of the brain. Roentgenograms made about three weeks after injury showed that the fragment moved freely downward when the patient was changed from the horizontal to the erect position. It was contained in an abscess cavity.

COMMENT

In a high percentage of cases of gunshot wounds of the head, it is not easy to decide when a metallic foreign body retained in the brain should be removed and when it should not. It has been the general policy among neurosurgeons to remove those which are large and those which are easily accessible at the time of primary debridement. In other instances it has been believed that more harm would be done to the patient by the operative trauma of removing the fragment than by allowing it to remain in its place of lodging. In a fairly large number of cases in which metallic fragments were not removed a brain abscess has developed around the foreign body. This occurs more frequently during the early weeks following injury than during later months and years.

The clinical signs of brain abscess secondary to a head injury are not always outstanding. Any finding which might lead to earlier diagnosis and treatment in these cases would appear to be of value. It has been found in this group of cases that gravitational movement of a metallic fragment in an abscess cavity may be demonstrated roentgenologically by examining the patient in both the horizontal and upright positions. The movement of a foreign

body during the interval between two roentgenological examinations also has been found to be associated with abscess formation.

Metallic foreign body movement has been demonstrated so frequently in the group of penetrating brain wounds studied that it is believed that all cases in which intracranial metallic fragments are not removed at the time of primary debridement should be re-examined roentgenographically at some time within the first two or three weeks following injury. Roentgenograms should be taken in both the horizontal and erect positions at each examination. These roentgenograms also should be compared carefully with any earlier films which are available for the detection of any change in position of retained metallic fragments. The development of symptoms suggesting an intracranial infection in association with a metallic foreign body is an indication for roentgen examination in erect and horizontal positions.

SUMMARY

1. Gravitational movement of foreign bodies retained in the brain may be demonstrated roentgenologically in some cases when the patient is changed from the horizontal to the upright position. In other instances evidence that movement has occurred can be observed when roentgenograms taken with the patient in one position are compared with those taken in a similar position after the elapse of an interval of time.

2. In 175 cases of penetrating wounds of the brain, 40 were found with retained intracranial metallic foreign bodies following primary debridement. In 4 instances (10 per cent) a change in position of the fragments was demonstrated on roentgen examination during the early weeks following injury. In all 4 cases this change in the position of the foreign body was due to a brain abscess.

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REFERENCES

1. BORDEN, W. C. The Use of the Röntgen Ray by the Medical Department of the United States Army in the War with Spain (1898). Government Printing Office, Washington, 1900.
2. CAIRNS, H. Head injuries in war, with especial reference to gunshot wounds, including a report on the late results in some of Harvey Cushing's cases of 1917. *War Med.*, 1942, 2, 772-785.
3. CUSHING, H. Notes on penetrating wounds of the brain. *Brit. M. J.*, 1918, 1, 221-226.
4. CUSHING, H. A study of a series of wounds involving the brain and its enveloping structures. *Brit. J. Surg.*, 1918, 5, 558-684.
5. CUSHING, H. Organization and activities of the neurological service American Expeditionary Forces. (In: The Medical Department of the United States Army in the World War. Maj. Gen. M. W. Ireland, Editor. Government Printing Office, Washington, 1927, Vol. XI, Part 1, 749-758).
6. EULENBERG, A. Kugeln im Gehirn; ihre Auffindung und Ortsbestimmung mittels Röntgenstrahlen-Aufnahmen., *Deutsche med. Wchnschr.*, 1896, 22, 523-525.
7. GAMLEN, H. E., and SMITH, S. A study of the inter-relation between the radiography and surgery of gunshot wounds of the head. *Brit. J. Surg.*, 1917, 5, 17-39.
8. HAYNES, W. G. Penetrating brain wounds. Analysis of 342 cases. *J. Neurosurg.*, 1945, 2, 365-378.
9. HAYNES, W. G. Transventricular wounds of the brain. *J. Neurosurg.*, 1945, 2, 463-468.
10. HAYNES, W. G. Extensive brain wounds. *J. Neurosurg.*, 1945, 2, 469-478.
11. JEFFERSON, G. Removal of a rifle bullet from the right lobe of the cerebellum; illustrating the spontaneous movement of a bullet in the brain. *Brit. J. Surg.*, 1917, 5, 422-424.
12. MALTBY, G. L. Penetrating craniocerebral injuries. Evaluation of the late results in a group of 200 consecutive penetrating cranial war wounds. *J. Neurosurg.*, 1946, 3, 239-249.
13. MARTIN, J., and CAMPBELL, E. H. Early complications following penetrating wounds of the skull. *J. Neurosurg.*, 1946, 3, 58-73.
14. MATSON, D. D., and WOLKIN, J. Hematomas associated with penetrating wounds of the brain. *J. Neurosurg.*, 1946, 3, 46-53.
15. MEYER, W. Skiagraph of bullets in the brain. *Ann. Surg.*, 1897, 25, 478.
16. PHELPS, C. Traumatic Injuries of the Brain and its Membranes. Appleton, New York, 1897, p. 347.
17. ROWE, S. N., and TURNER, O. A. Observations on infection in penetrating wounds of the head. *J. Neurosurg.*, 1945, 2, 391-401.
18. ULRICH, K. Doch Geschosswanderung? *Röntgenpraxis*, 1935, 7, 384-386.
19. VILVANDRE, G., and MORGAN, J. D. Movement of foreign bodies in the brain. *Arch. Radiol. & Electroth.*, 1916, 21, 22-27.
20. WEBSTER, J. E., SCHNEIDER, R. C., and LOFSTROM, J. E. Observations on early type of brain abscess following penetrating wounds of the brain. *J. Neurosurg.*, 1946, 3, 7-14.



SOME OBSERVATIONS ON DIFFUSE PULMONARY LESIONS

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THE problem of differential diagnosis of diffuse pulmonary lesions is a frequent one, often taxing the acumen of both clinician and roentgenologist. At this hospital† the difficulties in arriving at a proper solution have been impressive and stimulating. Although sometimes the answer is obvious, in many cases the etiology is determined only after exhaustive study or prolonged observation; in others, the explanation remains obscure until the time of necropsy. The complexity of the subject is best appreciated when one realizes the numerous diseases responsible for diffuse pulmonary lesions. The following table, based on accessible literature, although admittedly incomplete, has been found helpful.

TABLE I

DIFFUSE PULMONARY LESIONS—A CLASSIFICATION‡

I. CYSTIC LESIONS

- (a) *Congenital cystic disease*‡
- (b) Pulmonary pneumatocele (Peirce and Dirkse²⁴)
- (c) Neurocutaneous syndromes (*tuberous sclerosis*)

2. ASPIRATION

- (a) Hemorrhage
- (b) Drowning
- (c) *Lipoid pneumonia*
- (d) Changes secondary to achalasia or esophageal malignancy
- (e) Foreign bodies

3. INHALATION—PULMONARY EDEMA

- A. (a) Acetylene
- (b) Beryllium
- (c) Carbon tetrachloride
- (d) Kerosene
- (e) Nitric Acid
- (f) Phosgene

B. DUST—PNEUMOCONIOSIS

- (a) *Anthracosis* (coal dust)

- (b) *Bagassosis* (bagasse)
- (c) *Baritosis* (baryta)
- (d) Byssinosis (cotton lint)
- (e) Graphite (carbon)
- (f) *Siderosis* (iron)
- (g) *Silicosis* (silica), including chalcosis Potter's disease, and calcicosis (marble-cutter's disease)
- (h) Silicatosis (asbestosis)

C. LIPIODOL

D. THERMAL

4. DEPOSITION

- (a) *Xanthomatosis*
- (b) *Hemosiderosis*—mitral stenosis

5. EMBOLIZATION

- (a) Fat embolism
- (b) Multiple infarcts, septic or aseptic
- (c) Annular shadows due to bronchial artery occlusion (Sante and Hufford³¹)

6. TRAUMA

- (a) Blast
- (b) Pulmonary collapse complicating fractures of skull (Hodes and Groff¹⁶)

7. VASCULAR

- (a) *Chronic passive congestion*
- (b) *Pulmonary edema*
- (c) Pulmonary congestive changes due to nephritis (nephritic butterfly)

8. BRONCHIAL

- (a) *Atelectasis*
- (b) *Bronchiectasis*
- (c) *Chronic bronchitis*
- (d) Bronchial changes with cystic disease of the pancreas

9. INFECTIOUS

A. Bacterial:

- (a) *Pyemia*
- (b) *Bronchopneumonia*
- (c) *Brucellosis*
- (d) *Tularemia*
- (e) *Tuberculosis*
- (f) Syphilis (congenital)
- (g) Fusopirochetal
- (h) Glanders

B. Viral:

- (a) Atypical pneumonia
- Psittacosis

* Lt. Col., M.C., A.U.S., inactive.

† Based on experience at Percy Jones General Hospital and specially selected cases from civilian practice.

‡ Types most likely to cause miliary densities have been italicized.

C. Mycoses:

- (a) *Actinomyces*
- (b) *Aspergillosis*
- (c) *Blastomycosis*
- (d) *Coccidioidomycosis*
- (e) *Histoplasmosis*
- (f) *Moniliasis*
- (g) *Torulosis*
- (h) Toxoplasmosis

D. Others:

- (a) Tropical—paragonimiasis, *schistosomiasis*
- (b) Pulmonary alveolar adenomatosis
- (c) Amebiasis, ascariasis, echinococcosis

10. ALLERGIC

- (a) Tropical eosinophilia
- (b) Löfller's pneumonia
- (c) *Periarteritis nodosum*
- (c) *Disseminated lupus*

11. FIBROTIC

- (a) Acute diffuse interstitial fibrosis (Hamman and Rich¹¹)
- (b) Scleroderma
- (c) Irradiation fibrosis
- (d) *Bronchiolitis obliterans*
- (e) Pulmonary changes in drug addiction (Cole⁷)

12. HEMOPOIETIC

- (a) *Polycythemia vera*
- (b) Sick cell anemia
- (c) *Leukemia*

13. BOECK'S SARCOID

14. MALIGNANCY

- (a) Lymphogenous and hematogenous, metastatic malignancy
 - (1) *Sarcoma*
 - (2) *Carcinoma*
- (b) Lymphomatoid disorders
 - (1) Hodgkin's disease
 - (2) Lymphosarcoma

15. CALCIFIC

- (a) Hyperparathyroidism, vitamin D poisoning
- (b) Mycoses: aspergillosis, histoplasmosis, etc.
- (c) Mitral stenosis
- (d) Miliary tuberculosis
- (e) Metastatic osteogenic sarcoma with bone production
- (f) Arteriosclerosis

Certain aspects of the roentgenological appearance of such lesions may be of more or less value in differential diagnosis:

A. Size and Number of Lesions. What diagnostic significance, if any, can be attached to multiplicity of lesions and their size? Obviously, when considered alone, the total number of lesions present in the lung area is more often of prognostic than diagnostic importance. Neither is the actual size of the lesion of great value. These factors, though of no great importance independently, when evaluated together with clinical and other roentgenological data and interpreted in the light of past experience frequently enable one to reach a correct conclusion. The value of careful correlation is exemplified by the not infrequent discrepancy between the roentgen and clinical findings in individuals who, though in perfect general health, nonetheless show roentgen evidence of widespread pulmonary involvement. Under these circumstances, attention would be directed to such relatively benign lesions as Boeck's sarcoid, chronic miliary tuberculosis, or asymptomatic pneumoconiosis.

B. Appearance. The rather loose descriptive terminology encountered in the literature is often contradictory and confusing to the student. The various terms used to describe smaller lesions have included the following: stippling, beading, mottling, nodulation, pseudonodulation, accentuated vascular or linear markings, striation, fibrosis, reticulation, mesh, veil or honey-comb pattern, etc.

Experience teaches that it is unwise to draw sweeping conclusions on the basis of the roentgen density of a lesion. Frequently the statement is made that certain lesions, because of their relative radiodensity and the sharp demarcation of their borders, must be metastatic disease of sarcomatous or carcinomatous origin. A statement of this kind fails to take into consideration factors of roentgen technique such as applied kilovoltage, milliamperes-seconds employed, depth of respiration at the instant of exposure, true and false distortion, and many others.

When the pulmonary deposits are sharply demarcated and of the homogene-

ous density of "cannon balls," metastatic malignancy is likely. This, of course, is not a hard and fast rule. Similar shadows have been observed frequently in cases of pulmonary embolization, echinococcus disease, hemophilia,²⁶ cystic disease and multiple pulmonary abscesses prior to establishment of bronchial communication (Fig. 1, 2 and 14).

Although hematogenous metastatic disease can often be diagnosed readily, one unusual variety deserves mention: chorion-epithelioma. The pulmonary metastases in this disease show a marked tendency toward hemorrhagic infiltration or necrosis. In this event the pulmonary nodules lose their sharply margined contours and appear "soft" and fluffy. Such infiltrations, having lost their original appearance, are frequently indistinguishable from patchy bronchopneumonia or atelectasis. Fortunately, the history and physical findings are characteristic in many instances, the salient features being:

(1) History of tumor: mediastinal, retroperitoneal or testicular.

(2) Hemoptysis and rapidly progressing anemia.

(3) Gynecomastia.

(4) Very high urinary prolan, with prolan titer higher than 1,000,000 mouse units per liter (Powell method) (Fig. 3 and 4).

With regard to smaller lesions, to assume that a certain picture is typical of miliary tuberculosis, sarcoid, or lymphogenous malignancy may be fallacious. It should be emphasized that such widely divergent pathological entities as cystic disease and miliary tuberculosis may produce practically identical pulmonary pictures. From the work of Berg and Zachrisson,³ the difficulty encountered in differentiating between pulmonary cystic changes and miliary infiltrates of various origins is quite evident. In their illustrations, the cystic lung of tuberous sclerosis, acute and chronic miliary tuberculosis, sarcoid, silicosis, chronic passive congestion and lymphogenous carcinomatosis all show a similar basic pattern, which so far as we are con-

cerned is practically identical. The difficulty inherent in differential diagnosis of miliary carcinosis of the lung is another case in point. Rigler³⁰ states that in miliary carcinomatosis the lesions are "much sharper and more discrete and dense than miliary tuberculosis." On the other hand, it is Culver's opinion that in miliary tuberculosis "the lesions are usually more discrete . . . and have a more homogeneous density" than in carcinosis.⁸ It is quite probable that both authors are correct, as the roentgen appearance may change in different phases of the disease.

In the case of miliary disease, therefore, one must conclude there is no constant or absolutely diagnostic appearance. As indicated by Austrian and Brown,¹ miliary roentgen shadows may result from multiple causes. They state: "Generically . . . they occur whenever irritants—bacterial, viral, mycotic, chemical or neoplastic—find pulmonary or bronchial lodgment, whether by bronchial, vascular or lymphatic routes, or whenever disseminated pulmonary-vascular lesions, localized allergy or stasis in the lesser circulation occur." (See Table 1.)

C. Distribution. As a single entity in differential diagnosis, the distribution of pulmonary lesions may or may not be helpful. One might expect the disturbed dynamics underlying pulmonary edema to give a relatively constant pattern of distribution, but this does not prove to be the case. The usual roentgenologic appearance is one in which the periphery of the lung fields is clear in both posteroanterior and lateral roentgenograms. Centrally there is a symmetrical butterfly-shaped opacity, most radiodense at the hila, but fading toward the periphery, the clear periphery apparently being due to the mechanics of respiration and the massage action of the pleura (Fig. 8). However, as was so aptly demonstrated by Nessa and Rigler,²⁹ many exceptions to this characteristic distribution exist, leading to frequent diagnostic errors. In order to obviate such mistakes, it must be remembered that pulmonary edema need not be diffuse, but may be asymmetrical and,

indeed, entirely localized to one lung or even an upper lobe.

The tendency for infarcts to involve the periphery of the lobes adjacent to several pleural surfaces has been known for many years. The importance of this feature has been emphasized in the current literature by Hampton and Castleman.¹³ Multiple projections, including lateral views, are often essential if one is to determine not only the shape of the lesion, but also its proximity to major and minor fissures.

Pulmonary lesions of silicosis often seem to have a characteristic distribution, although this varies with the stage of the disease. According to Pendergrass,²⁵ the earliest fibrotic lesions are distributed in or along lymphatic channels, and may become parenchymal in position. In the relatively early phase of the disease described by Pancoast and Pendergrass^{22,25} as peribronchial perivascular lymph node predominance, the nodules tend to spare the periphery due again to the above described massage action of the ribs. However, eventually the centrifugal lymphatics become involved and subsequently massive coalescent or tuberculoid nodules may make their appearance in the upper or apical portions of the lung fields (Fig. 9 and 10).

Changes largely confined to the bases and inner thirds of the lung fields are produced by so many disease entities, both common and rare, that the finding of such distribution is not in itself particularly diagnostic. Among the conditions to be considered in differential diagnosis are such common ones as chronic passive congestion, bronchitic disease, bronchiectasis and aspiration pneumonia. Less commonly, scleroderma,^{19,33} fibrocystic disease of the pancreas,² periarthritis nodosa,⁹ erythremia,¹⁵ ascariasis,^{18,29} and drug withdrawal⁷ are encountered. The commoner lesions are too well known to merit further consideration. It is not within the scope of this paper to dwell at length on the numerous rare conditions which are alleged to have this characteristic roentgenographic distribution.

During the last three years, numerous

cases of teratoma of the testis and osteogenic sarcoma in younger individuals have been under our care. Of considerable interest and practical importance is the fact that early pulmonary metastatic deposits are often observed first in the costophrenic sulci, or partially obscured by the superimposed cardiac silhouette, stomach bubble, or domes of the diaphragm (Fig. 11). This diagnosis has so often been made in retrospect after the lesions show generalization, that it behooves the examiner to give especially careful consideration to such areas before a negative report is rendered. Careful roentgenoscopy, spot roentgenograms, and oblique studies are often required before one can be certain of the correct diagnosis.

D. Progression and Retrogression. The rapid progression in size or, on the other hand, regression or disappearance of pulmonary lesions over a period of days or weeks, as contrasted with months or years, may be of considerable diagnostic aid. In this regard, the importance of properly spaced serial roentgenograms cannot be too greatly stressed. The usual type of "cannon ball" metastatic malignancy, in our experience, progresses quite rapidly to a fatal termination in weeks or months. It has been observed that the most rapid evolution of such cases is in young patients with teratoma of the testis, whose pulmonary lesions were previously held in check or caused to regress temporarily by palliative roentgen therapy. So far, in no case with metastatic malignancy above the domes of the diaphragm have we observed more than transient retrogression of the pulmonary lesions, although complete clearing of the lung fields was accomplished on five different occasions. The primary lesion in these patients was teratoma of the testis. Pulmonary metastasis in this disease is relatively frequent, having been noted in 20 of 109 cases when first admitted to this hospital (Fig. 12 and 13).

By contrast, parasitic disease may remain stationary over a period of years (Fig. 14), while many pulmonary infarcts, once

apparent, heal within periods varying from days to weeks. Although postmortem confirmation is lacking in those cases of infarction which show roentgen evidence of rapid resolution, such shadows have been designated as "incomplete infarcts" by Hampton and Castleman¹³ on the assumption that no necrosis of the alveolar walls can be demonstrated.

Additional examples of the importance of serial studies may be mentioned. It is well known that in early phases of pulmonary edema the roentgen picture simulates miliary disease due to other causes. Subsequently, when the miliary lesions become large and confluent, within hours or days, the possibilities in differential diagnosis are narrowed appreciably and a correct interpretation can more easily be rendered. Both rapid progression and clearing of pulmonary lesions are commonly encountered in acute illnesses as exemplified by atypical pneumonia, lipoid embolism (Fig. 16 and 37), and as noted in certain cases of Löffler's syndrome (Fig. 18 and 19). The above phenomena are in marked contrast to such diseases as pneumoconiosis, where pulmonary lesions may undergo little or no change over a period of years.

The examples given are only a few of many which might be quoted. Fundamentally, a certain disease may show marked variation in appearance and distribution from individual to individual, but the pattern of progression and regression may be so characteristic as to suggest the probable diagnosis.

E. *Mediastinal Enlargement and Increased Prominence of the Hilar Shadows Associated With Pulmonary Lesions.* Although it is true that the mediastinal and hilar nodes are involved in many types of acute pulmonary infection, rarely is there associated roentgen evidence of significant mediastinal lymphadenopathy in adults. This fact has recently been stressed by Paul,²³ who states that "roentgenologically, such lymphadenopathy is of relatively little importance." One exception to this general rule merits consideration. Bihss and

Berland⁵ suggest that in ulceroglandular and oculoglandular tularemia, hilar adenopathy is manifest in the earlier stages of the disease with subsequent appearance of pulmonary lesions, which arise presumably due to retrograde lymphatic spread (Fig. 15).

In children it is well known that the hilar shadows are frequently accentuated during acute lower respiratory infections. Therefore, great caution must be exercised in distinguishing between normal variants of the hilar structures and so-called "hilar adenopathy," which are often differentiated with difficulty.

In more chronic pulmonary infection, such as tuberculosis and the pneumomycoses, pulmonary lesions with concomitant mediastinal and hilar enlargement are common. Likewise, lymphomatoid disorders, metastatic carcinoma and Boeck's sarcoid may give rise to similar pathological changes. The difficulty in distinguishing between the members of the lymphoblastoma group has been stressed in the current literature.^{6,23,30} Caffey⁶ states: "The primary lymphoblastomas include lymphosarcomas, Hodgkin's disease and leukemic hyperplasias. All have essentially the same roentgen characteristics, and their differentiation by roentgen visualization is rarely possible."

Because of the widespread distribution of the mediastinal lymph nodes, involvement of these structures may result in a variable roentgen-ray pattern, depending on whether several or all of the nodes are involved. In this regard, it is noteworthy that Hodgkin's disease may present itself as a moderate enlargement of single groups of mediastinal nodes. According to Rabin,²⁸ who has observed a large series of Hodgkin's cases . . . "it appears that enlarged paratracheal lymphnodes are the ones most frequently observed on the film." True as this statement may be, *one should not infer that every case with such paratracheal enlargement is one of Hodgkin's disease* (Fig. 20, 21, 22). It is self evident, therefore, that different diseases, affecting the same group of

lymph nodes in the same general manner, will produce an identical roentgen picture. Thus, such dissimilar conditions as lymphoblastoma, sarcoid, and even metastatic teratoma of the testis may mimic one another. A case of idiopathic pulmonary fibrosis recently encountered in this hospital was characterized by such diffuse pulmonary and mediastinal changes that the differential diagnosis included, among others silicosis, silicotuberculosis, and coccidioidomycosis (Fig. 23 and 24).

Before leaving this topic, it should be recalled that hilar enlargement often results from diseases involving structures other than lymph nodes. Mention should be made of such conditions as chronic passive congestion, periarteritis nodosa, pulmonary infarction, etc., which may result in enlargement of the pulmonary vessels with consequent increase in the root shadows. Practically speaking, lymph nodes and large truncal shadows near the mediastinum are often indistinguishable. The problem of hilar and associated truncal enlargement is not a simple one. As pointed out by Pendergrass:²⁵ "Slight to moderate variation in these shadows is often difficult to evaluate." The chances for error in interpretation depend to a large extent on the technique used and the effort expended by the examiner. The personal equation plays an important role, the same individual rendering different reports on the same roentgenogram on different days.

Space does not permit a complete consideration of all conditions listed in Table I. However, several additional points deserve clarification:

The presence of multiple pulmonary calcific foci has heretofore been frequently considered due to pre-existing, well healed miliary or submiliary tuberculosis, or a Ghon's complex. Geever¹⁰ feels that tuberculo-allergy may become spontaneously extinguished or depressed, and that the infection, having occurred many years before, becomes completely healed. He noted that as a cause for such calcifications . . . "the importance of tuberculosis should not be

minimized." From the practical standpoint however, it seems unwise to label unequivocally such shadows as tuberculous in origin, when the subject still remains so controversial.

Doubt has been expressed regarding the tuberculous origin of such lesions by Olson, Wright and Nolan,²¹ who suggest *Ascaris* as a possible causative agent. A close relationship between the high incidence of pulmonary calcification and the prevalence of *Ascaris lumbricoides* in the Appalachian Plateau and its foothills has been pointed out.

A recent review³⁴ stresses the prevalence of pulmonary calcification associated with tuberculin anergy and histoplasmin sensitivity. It is not unlikely, therefore, that histoplasmosis, particularly in certain areas of the Mississippi River Basin, accounts for an appreciable number of diffuse calcareous lesions in the lung fields.

Practically speaking, it is important to remember, in weighing the relative merits of the different concepts of pathogenesis of pulmonary calcium deposits, that such a simple factor as incorrect evaluation of blood vessel shadows seen on end may nullify sweeping conclusions based on statistical analyses.

REPORT OF CASES

CASE 1. *Pulmonary Embolism Simulating Metastatic Disease* (Fig. 1 and 2).

A medical officer aged thirty-four noted anorexia, malaise and weight loss in August, 1942. This was attributed by him to salt loss and inadequate diet. Consequently, medical aid was not sought. On August 13 he ran approximately a mile, and though rather fatigued following this unusual exertion, he noted no particular after-effects. On the following day he had occasion to have a routine roentgenogram of the chest made. Because of the presence of rounded densities in both lung fields, he was hospitalized. Past history disclosed the fact that preceding the onset of his illness, he had suffered from external hemorrhoidal thrombosis on four different occasions, and had had thrombi excised twice.

Low grade fever was present for the first few days following hospitalization. The sedimen-

tation rate was elevated and a moderate degree of secondary anemia was present. Roentgenographic studies of the skeleton, gastrointestinal and urinary tracts were negative. The patient was returned to the zone of interior with a diagnosis of metastases to both lung fields, primary site undetermined. The possibility of pulmonary infarction was considered but felt to be unlikely.

He was admitted to another general hospital where further investigation gave no additional information. Approximately three weeks after the original roentgenograms, the patient experienced severe pleuritic pain in the left lower chest with radiation to the left shoulder. He developed a non-productive cough. Roentgenograms now showed the lesion in the left lower lobe to have become attached to the mid-portion of the diaphragmatic leaf, which was now moderately elevated. The costophrenic sulci remained clear.

A repeat roentgenographic study thirty days later showed that one of the lesions had completely disappeared and the remainder had shown some regression. Phlebograms at this time showed patent veins throughout both lower extremities.

The patient returned to duty. He has been



FIG. 1. Laminagraphic study of a medical officer, aged thirty-four, with history of fatigue and low grade fever, originally thought to have metastatic malignancy. Sequential films proved this to be a case of pulmonary infarction. Note the large "cannon ball" lesions at both bases.



FIG. 2. Lateral roentgenogram of same case as Figure 1, showing close approximation of nodular shadows to the major interlobar fissures.

entirely well to May, 1946. Six months after the lesions were first noted roentgenograms were negative except for mild residual parenchymal scarring in areas previously occupied by the infarcts.

Discussion. This case, reported elsewhere by Hampton,¹² demonstrates that several months of observation may be necessary before the cause of "cannonball" lesions can be determined. In this instance the infarcts showed no appreciable change over a three month period. In our experience pulmonary metastatic disease may be held in check for a comparable length of time after deep roentgen therapy. The lateral roentgenogram was of inestimable value in determining the etiology of the pulmonary shadows.

CASE II. *Chorionepithelioma* (Fig. 3).

A soldier, aged twenty-four, was admitted to Percy Jones General Hospital on June 21, 1944. Family history revealed that his mother and two maternal aunts had died of carcinoma of the breast.

In February, 1944, he developed "flu," characterized by fever, aches and malaise. Following this he had persistent cough, hoarseness and hemoptysis. In March he noted puffiness of the face, swelling of the veins of the neck and dyspnea. His collar size increased from No.



FIG. 3. Diffuse pulmonary lesions simulating infection. This patient originally complained of hoarseness, hemoptysis, and increase of collar size. He had a large mediastinal mass, which promptly disappeared following roentgen therapy, but subsequently developed extensive hematogenous metastases, as shown above in the portable roentgenogram. The "soft" appearance is due to hemorrhage and necrosis within the lesions. Proved case of chorionepithelioma.

14 to 15. In April the veins of the chest and arms became prominent and his breasts became enlarged. He was hospitalized on June 10. Roentgenograms showed a large mediastinal mass. There was evidence of superior venacaval obstruction. The venous pressure in the arms approximated 400 mm. of water. He was admitted to this hospital with a transfer diagnosis of chorionepithelioma.

Physical examination on admission confirmed the presence of the superior venacaval obstruction and gynecomastia. Clear fluid could be expressed from the nipples. Urinary prolactin was 1,500,000 mouse units per liter.

Deep roentgen therapy was instituted and after three treatments there was striking recession of the tumor, prompt disappearance of signs of obstruction of the superior vena cava and diminution in size of the breasts. A single pulmonary metastasis was visible in the left costophrenic sulcus in August. In October, anemia and a diffuse seeding of the lungs were observed, the pulmonary lesions showing marked progression in size by the time of death on October 27, 1944.

Autopsy disclosed a chorionepithelioma in

the upper anterior mediastinum, measuring 5×5×4 cm. As no involvement of the testes or retroperitoneum was found, it was felt that the tumor was primary in the mediastinum. There were extensive metastases in lungs, liver and eleventh and twelfth thoracic vertebrae. The pulmonary tumor nodules were sharply circumscribed and ranged from pea to acorn in size. Viable tumor cells were confined to the periphery, the remainder of the nodule being completely necrotic and containing blood.

Discussion. In our experience, rapid progression of anemia, high urinary prolactin titer and profuse hemoptysis are pathognomonic of chorionepithelioma in young adults. The marked hemorrhage and necrosis in the lesions apparently accounts for their hazy outline on the roentgenograms. A striking clinical feature is the anemia explained by hemorrhage within the tumor nodules. We have been disappointed by the poor response of this type of tumor to deep roentgen therapy. The following case of chorionepithelioma presented a strikingly similar roentgen and clinical picture.

CASE III. *Chorionepithelioma* (Fig. 4).

This officer, aged twenty-nine, was admitted to Percy Jones General Hospital on September 30, 1944. In June, 1943, he noted a small, hard lump in the right testis. Within a few months the entire testicle was somewhat swollen and intermittent low backache was noted. Lumbar pain became severe in April, 1944, and led to hospitalization at an army general hospital on May 1, 1944. Three days later an orchiectomy, together with extensive resection of the periaortic lymph nodes, was carried out. He then received deep roentgen therapy over the inguinal regions, abdomen and chest until September 1, at which time therapy was discontinued. He had now lost 30 pounds in weight and complained of discomfort in the right upper quadrant, bladder region, left lower quadrant and left hip. While on leave in September he rapidly became worse and was admitted to this hospital.

On admission there was evidence of marked weight loss, dehydration and moderate icterus. The liver edge was irregular and tender.

Laboratory studies were as follows: red blood cell count, 2,100,000; hemoglobin, 46 per cent; icteric index, 31; urinary prolactin 1,500,000 mouse units per liter.

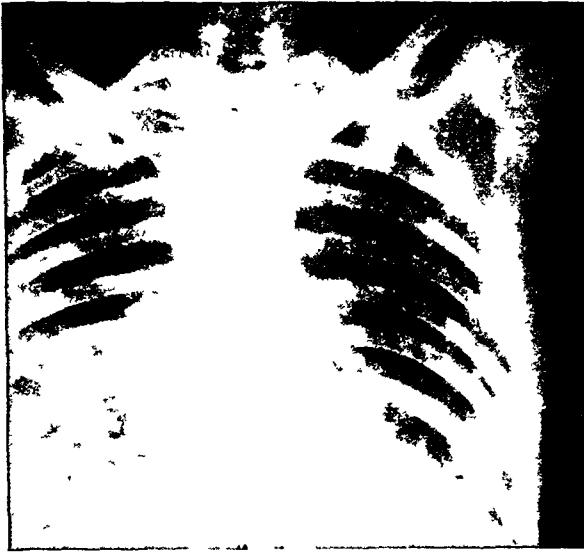


FIG. 4. Bedside examination. Diffuse pulmonary lesions simulating infection in officer, aged twenty-nine, with history of tumor of the right testis. Urinary prolan 1,500,000 mouse units per liter (Powell method). Diagnosis: Extensive metastatic chorionepithelioma with extreme degree of hemorrhage and necrosis.

His course was retrogressive, characterized by the presence of low grade fever, tachypnea, hemoptysis and increasing jaundice. Death occurred on October 8, 1944.

Necropsy revealed extensive metastatic chorionepithelioma of the retroperitoneum, liver and lungs. An extreme degree of hemorrhage and necrosis was found in the metastatic lesions. Throughout the pulmonary parenchyma were numerous round pea to walnut sized tumors. The pulmonary nodules were so hemorrhagic and necrotic that the roentgen picture suggested a diffuse bronchopneumonic process.

Discussion. This case differed from Case II only in that the gynecomastia was absent.

CASE IV. *Bronchogenic carcinoma* (Fig. 5).

A colonel, aged fifty-three, was first hospitalized in January, 1943. The family history revealed that his father had died of cancer of the sigmoid at fifty-five and a sister of carcinoma of the breast at fifty.

In September, 1942, the patient experienced pain and localized tenderness along the lateral aspect of the right foot. Subsequently he noted a dull pain in the lower dorsal spine radiating around the tenth rib into the left upper quadrant. In January, 1943, physical examination revealed scoliosis of the spine and point tender-

ness over the right cuboid bone. Roentgen examination showed lytic areas in the left tenth dorsal pedicle and right os cuboid. Chest roentgenograms revealed a nodular lesion in the left upper lobe which simulated a slightly calcified primary Ghon's focus. Biopsy of the os cuboid led to a diagnosis of adenocarcinoma of unknown origin. He received roentgen therapy throughout February, 1943, with marked improvement of symptoms, regression of the pulmonary lesion and improvement in appearance of the skeletal lesions.

He was discharged to duty on March 30, 1943, and returned in June, feeling well. The tenth dorsal vertebra had completely recalcified, but roentgenograms now showed involvement of the pedicles of D-5 and D-7. The lesions each received 3,200 r (with backscatter). Subsequent films showed healing taking place.

On November 22, 1943, he was readmitted complaining of marked sacral pain. Roentgenograms revealed a large lytic lesion with complete destruction of all sacral segments. Deep roentgen therapy induced complete relief of pain, and he was again discharged from the hospital.

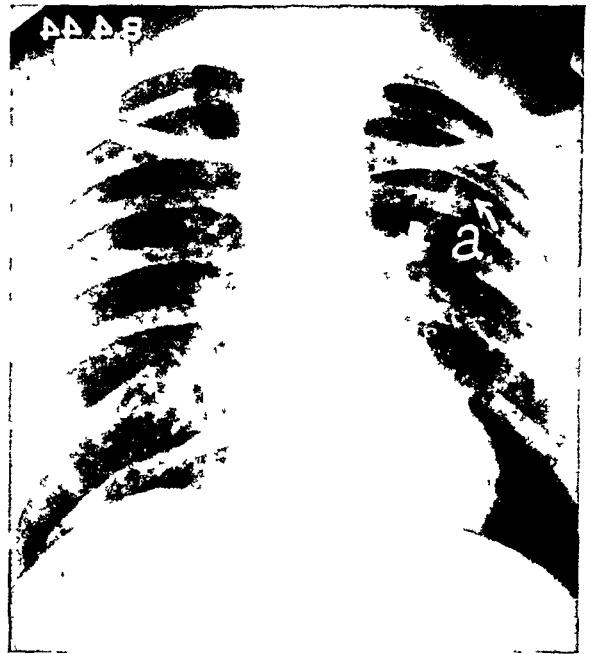


FIG. 5. Diffuse submiliary lesions in officer, aged fifty-three. His first complaint was pain in the region of the right os cuboid, followed shortly by distress in the region of the left tenth rib. The densities in both lung fields represent metastases from the primary pulmonary neoplasm shown at *a*. This lesion is not prominent, as it has regressed following deep roentgen therapy.

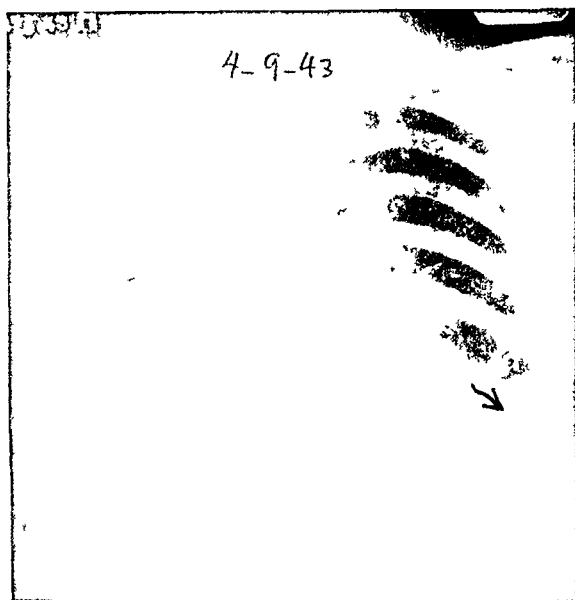


FIG. 6. Bronchogenic carcinoma simulating miliary tuberculosis in a soldier, aged forty-one, with history of bilateral inguinal pain, alternating hydrothorax and symptoms of embolism. Primary lesion proved to be a small papillary adenocarcinoma of the right upper lobe bronchus.

He was readmitted on March 11, 1944, complaining of severe retro-orbital pain, nausea and vomiting. Numerous focal areas of destruction were now apparent in the calvarium. The previously involved osseous structures appeared more densely calcified. Symptomatic relief followed roentgen therapy.

During the next year he continued to develop numerous lucid defects in the skull, vertebrae and ribs. Lesions were also noted in the right tibia and left femur. In March, 1944, examination of the lungs showed recurrence of the primary pulmonary lesion, and, in addition, miliary lesions became manifest in both lung fields. There were no pulmonary complaints. Palliative roentgen therapy was given at various times but had to be discontinued at intervals because of evidence of bone marrow exhaustion. He gradually lost weight and strength. In November, 1944, signs of cerebral metastasis were evident, dominating the clinical picture during the remaining months of life. Death occurred May 3, 1945, thirty months after the onset of symptoms.

Autopsy revealed bronchogenic carcinoma (adenocarcinoma type) of the left upper lobe with extensive metastases to bone, brain, liver, lungs, regional lymph nodes and adrenals. The

primary lesion was found in the wall of a branch bronchus, adjacent to a calcified lymph node containing a caseous center surrounded by scar tissue. The innumerable pulmonary metastatic deposits were found to be 3 to 5 mm. in size.

Discussion. The prolonged course, the mineralization of the skeletal lesions, and the prompt disappearance of the primary lung tumor following deep roentgen therapy were striking. Relief of pain was dramatic and enabled the patient to continue in a useful capacity during the major portion of his illness. The fact that the primary neoplasm originated at the site of an old tuberculous scar is noteworthy. A case with a somewhat similar roentgen picture, suggesting miliary tuberculosis and presenting a problem in differential diagnosis, was recently encountered.

CASE V. Bronchogenic Carcinoma Simulating Miliary Tuberculosis (Fig. 6 and 7).

This soldier, aged forty-one, was admitted to Percy Jones General Hospital on July 8, 1943. In March, 1943, he developed cough, bilateral inguinal pain and fever, and then improved. In April, symptoms recurred and were soon followed by pleurisy and hemoptysis. When hospitalized early in April, 1943, there was evidence of femoral thrombophlebitis. Roentgenograms showed the presence of bilateral pleural



FIG. 7. Same case of Figure 6, showing miliary lesions in the lateral projection.

effusion, but, in addition, miliary lesions were noted throughout both lung fields, suggesting the diagnosis of miliary tuberculosis.

On admission to this hospital there were signs of thrombosis of the inferior vena cava. Numerous thoracenteses yielded a serosanguineous fluid. He continued to complain of recurrent pleurisy and pain along the right femoral vein. On July 13, he developed an embolus of the right radial artery, and three days later a cerebral embolus resulted in aphasia and right hemiparesis. He was markedly emaciated at the time of death on July 27, 1943.

Necropsy revealed a small primary papillary adenocarcinoma of the right upper lobe bronchus with diffuse adenocarcinomatosis of both lungs, the miliary lesions being quite small and uniform in size. Metastases were present in the hilar nodes, pleura, liver, kidney and adrenals. There was an organizing thrombus of the femoral, common iliacs, and the lower portion of the inferior vena cava. Also worthy of interest was the terminal non-bacterial thromboendocarditis of both mitral and tricuspid valves which had resulted in emboli to the splenic, left renal, right radial and left coronary arteries. A necrotic area of infarction in the left lower lobe had ruptured into the pleural cavity, producing an encapsulated empyema.

Discussion. The primary neoplasm was found only after careful search. The presence of a thrombophilic diathesis in association with malignancy is well exemplified by this case. Even so, this was a most difficult diagnostic problem, not completely solved until autopsy.

CASE VI. *Pulmonary Edema* (Fig. 8).

This soldier, aged twenty-nine, was admitted to Percy Jones General Hospital on January 28, 1946. From April, 1944, until March, 1945, the patient was a German prisoner. When liberated, he was hospitalized with complaints of weakness, recent rapid weight loss, dyspnea on exertion and generalized edema. The red blood cell count measured 2,700,000 per cu. mm. and hemoglobin 4.5 gm. per 100 cc. The response to transfusions, diet and vitamins was inadequate. Further study demonstrated a diverticulum-like lesion of the third portion of the duodenum.

On October 9, 1944, the duodenum and head

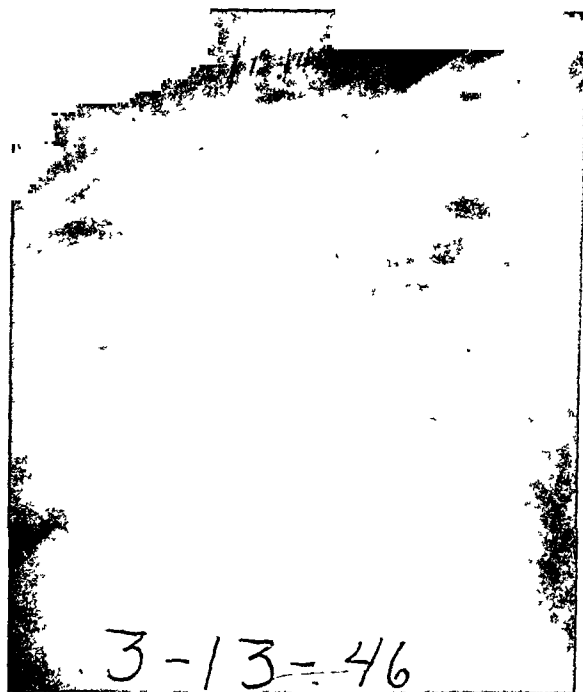


FIG. 8. Diffuse pulmonary edema in soldier, aged twenty-nine, which appeared two days following incision and drainage of a huge abscess in the left abdominal gutter. Patient had a 4 plus albuminuria and innumerable red blood cells in the urine, but no urea retention. Note the rather characteristic butterfly pattern.

of the pancreas were resected and the stomach and common duct anastomosed to the jejunum. The tumor, which proved to be a leiomyoma of the duodenum with low grade sarcomatous changes, was completely removed. An incisional biliary fistula developed postoperatively.

On admission to this hospital, physical examination was negative except for the presence of mild anemia and slight drainage from the fistula. On February 20, 1946, he developed painless jaundice and clay-colored stools. On February 28, because of signs of complete obstruction, the common duct was explored and two small stones removed. A cholecystojejunostomy was performed. Signs of epigastric peritonitis, a temperature of 103°, and respirations of 30 developed postoperatively. On March 2 a Penrose drain was inserted into the region of the common duct without improvement. On March 6, in spite of rapid diminution of his jaundice, he failed to gain. Signs of bilateral lower lobe consolidation now appeared. The roentgenogram and clinical picture were compatible with lower lobe atelectasis resulting



FIG. 9. Reported through the courtesy of Dr. E. P. Pendergrass. Chest of hard coal miner, aged forty-four, who had never used a jack hammer and had drilled very little in rock. The roentgenogram is rather characteristic of pneumoconiosis without infection. Patient relatively asymptomatic.

from elevated diaphragms. During the previous seven days he had received 17 liters of sodium chloride intravenously, and the whole blood level was found elevated to 590 mg. per 100 cc. All salt was discontinued and human serum albumin was substituted. Between April 6 and 15 he received 625 gm. (25 ampules) of this substance. Under this management the total blood proteins rose from 4.8 to 6.9 and the serum albumin from 3.4 to 4.7.

On May 11, a huge abscess in the left abdominal gutter was drained. Though temperature now fell towards normal, dyspnea became more marked and the patient was delirious at times and at times lethargic. By May 13 signs of consolidation had almost disappeared at both bases, but rales were now present over both anterior lung fields. A roentgenogram dated March 15 showed diffuse pulmonary edema. His urine, previously negative, now showed 4 plus albuminuria and innumerable red blood corpuscles. During the next two weeks the chest cleared and his subsequent course was uneventful, except for persistence of marked albuminuria. At no time was there urea retention, peripheral edema, hypertension, or increase in anemia. The urinary specific gravity was within normal limits. Therapy included penicillin, streptomycin and oxygen.

Discussion. The roentgen picture in this case is characteristic of pulmonary edema. During his early postoperative course he received excessive amounts of sodium chloride, which apparently resulted in fluid retention without oliguria, evidence of urea nitrogen retention, or diminished CO_2 combining power. At this critical stage administration of human serum albumin mobilized excessive fluid into the blood stream. This process was enhanced by impaired urinary secretion due to nephritis. It should be noted that the serum albumin given contained approximately 0.1 gm. of mercury and also sodium chloride. His subsequent course has not been characteristic of mercury nephrosis. The normal blood urea nitrogen rules out the presence of a true nephritic "butterfly."

The following 2 cases are quite characteristic of the roentgen findings in pneumoconiosis with and without infection:

CASE VII. *Anthracosilicosis without Infection* (Fig. 9).

This man, aged forty-four, had been a hard coal miner and was seen in consultation by Dr. E. P. Pendergrass. He worked in a coal mine for nineteen years and used hand tools. He never

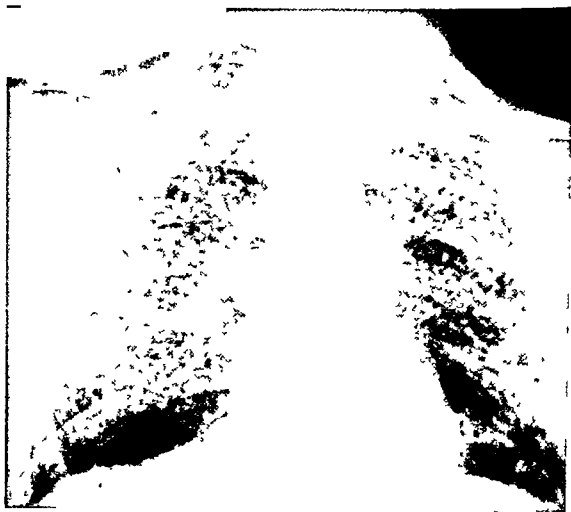


FIG. 10. Reported through the courtesy of Dr. E. P. Pendergrass. Anthracosilicosis with infection. Note the extensive tuberculoid lesions in both subapical regions. Patient packed slate in breakers for four years and subsequently was employed as a hard coal miner for fifteen years.

used a jack hammer and drilled very little in rock. His only complaints were those of nervousness, ill-defined pains, vomiting and "gas." The roentgenogram is rather typical of pneumoconiosis without infection.

CASE VIII. *Anthracosilicosis with Infection* (Fig. 10).

This man, aged forty-three, was seen by Dr. E. P. Pendergrass in civilian life.

Past History. At the age of twenty he was found to have pulmonary tuberculosis and was sent to a sanatorium.

The following occupational history is of significance: He began work at the age of eleven. His job consisted of packing slate in breakers for four years, following which he worked as a hard coal miner for fifteen years. During the past eight years he was not employed. Patient came into the hospital as a brain tumor suspect. No tubercle bacilli could be demonstrated, even after bronchoscopic examination. In spite of this, the roentgen picture is characteristic of silicosis with infection, likely due to tuberculosis.

CASE IX. *Metastatic Osteogenic Sarcoma* (Fig. 11).

This corporal, aged twenty-one, was admitted to Percy Jones General Hospital on April 7, 1946, with a large tumor of the lower

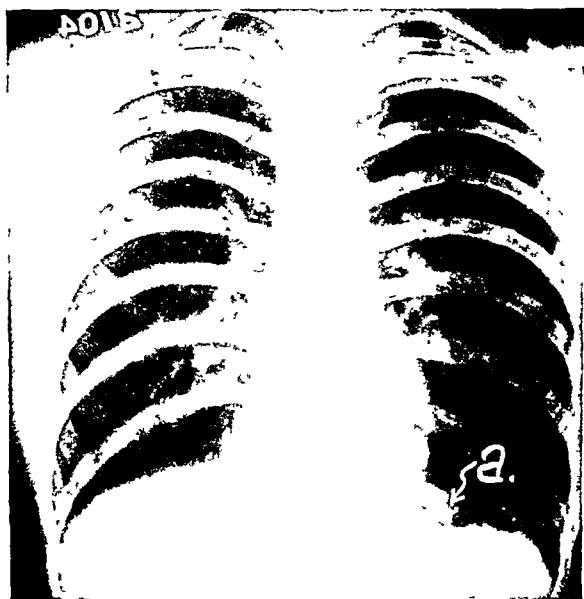


FIG. 11. Early pulmonary lesion superimposed on left eleventh rib and demonstrated in the region of the stomach bubble at *a*. Confirmed by roentgenoscopy and films made in multiple projections.



FIG. 12. Multiple metastases in the lungs from embryonal adenocarcinoma of the left testis.

third of the right femur. The left thigh measured 33 cm. and the right 44 cm. There was marked enlargement of the veins of the lower thigh and marked increase in local heat. The tumor was firm, about the size of a small grapefruit, and was attached to the underlying bone. Roentgenograms of the right femur revealed a large osteogenic tumor involving the femoral shaft near the junction of the middle and distal thirds. Sun-ray periosteal formations were seen extending into the soft tissues both mesially and laterally. The medullary canal appeared partially obliterated by bone condensation changes. The appearance was quite characteristic of an osteoblastic sarcoma. A chest roentgenogram revealed a 2×1 cm. shadow behind the stomach bubble, which was subsequently proved to be a metastatic lesion by means of careful roentgenoscopy, spot roentgenograms and special oblique projections.

Discussion. This case demonstrates the necessity of careful scrutiny of chest roentgenograms prior to amputation in malignant tumors of bone. Without painstaking fluoroscopy of the lung fields the proper diagnosis could not have been made.

CASE X. *Teratoma of the Testis* (Fig. 12 and 13).

This private, aged thirty-four, was admitted to Percy Jones General Hospital on January 17, 1945. In August, 1944, he injured his left testis.

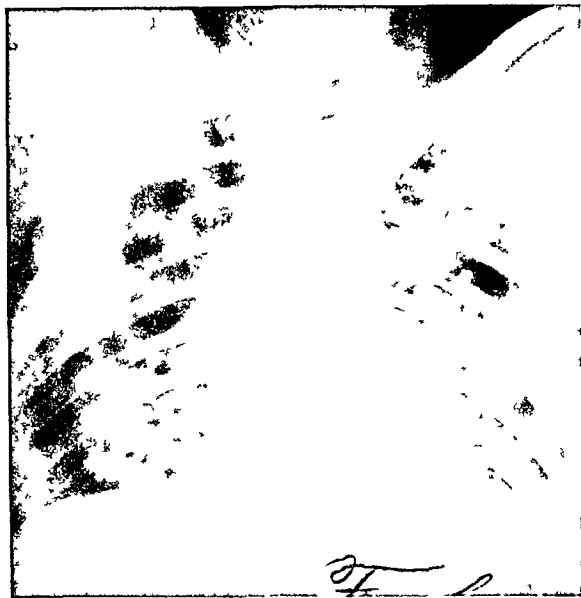


FIG. 13. Same case as Figure 12. Bedside roentgenogram of the chest four weeks later showing marked increase in size of lesions.

In December, 1945, the left testicle became enlarged to several times its normal size and was firm in consistency.

On admission to the hospital the above observations were confirmed. In addition, there was left supraclavicular adenopathy. On January 24, roentgenograms showed metastases in both lung fields. Deep roentgen therapy was followed by complete regression of the supraclavicular mass and improvement in the pulmonary lesions. The urinary prolan was greater than 3,000 mouse units. On May 2 an orchiectomy was performed. In June he complained of severe pain in his back and chest, which was relieved by roentgen therapy. The pulmonary lesions progressed and his condition gradually deteriorated. Death occurred on September 16, 1945.

At necropsy both lungs were studded with innumerable metastatic foci ranging from 0.5 to 6 cm. in diameter. There was marked involvement of the lumbar, inguinal, periaortic, and tracheobronchial lymph nodes. Metastases were present in the left kidney, the diaphragm, spleen and liver. The microscopic diagnosis was embryonal adenocarcinoma.

Discussion. This case illustrates the futility of any type of therapy in the face of pulmonary metastases. The rapid increase in size of the lung lesions in the period of

one month is not uncommon, particularly following initial regression due to deep roentgen therapy.

CASE XI. Possible *Echinococcus* Disease (Fig. 14).

This patient's roentgenogram and clinical history are included through the courtesy of Dr. C. C. Hoffman of Hartford, Connecticut:

A fifty-four year old white business man first noted symptoms in April, 1930. There was dyspnea, loss of strength, tachycardia and cough with intermittent expectoration. On physical examination there were areas of dullness and inconstant rales over the lung fields. The heart was not enlarged. A roentgen diagnosis of carcinoma of the lungs was made and a course of deep roentgen therapy instituted.

During the next ten years roentgenograms were made at approximately yearly intervals and showed an unchanging pulmonary picture. Scattered throughout the left pulmonary field are noted eight moderately dense cystic spherical lesions, each measuring 3 cm. in diameter. In the right pulmonary field are approximately the same number of lesions tending to, overlap one another. Each lesion shows a tend-



FIG. 14. Reported through the courtesy of Dr. C. C. Hoffman. Chest of businessman, aged fifty-four, with history of tachycardia, dyspnea and intermittent expectoration. No change in the number, size or appearance of the lesions has been demonstrated by roentgenograms made at yearly intervals during the last ten years.

ency toward irregular central calcification. These films have been seen by many roentgenologists who have speculated as to the possible diagnosis. Most of them have stressed hydatid or congenital cyst as the most likely possibility. The patient has had only minor complaints over the years and is in good general health at the present time.

Discussion. This case again exemplifies the fallacy of assuming that nodular shadows in the lung fields are always malignant in origin. Due to error in the original interpretation, the patient received an unnecessary course of deep roentgen therapy. This man has only minor complaints at the present time.

CASE XII. *Chronic Tularemia* (Fig. 15) (Courtesy of Lt. Col. John L. Dixon).

A grocer, aged fifty-five, entered the office of Dr. John L. Dixon in the summer of 1939, with a history of having had an ulceration of his right forefinger six years before. The ulcer was followed by intermittent suppurative axillary

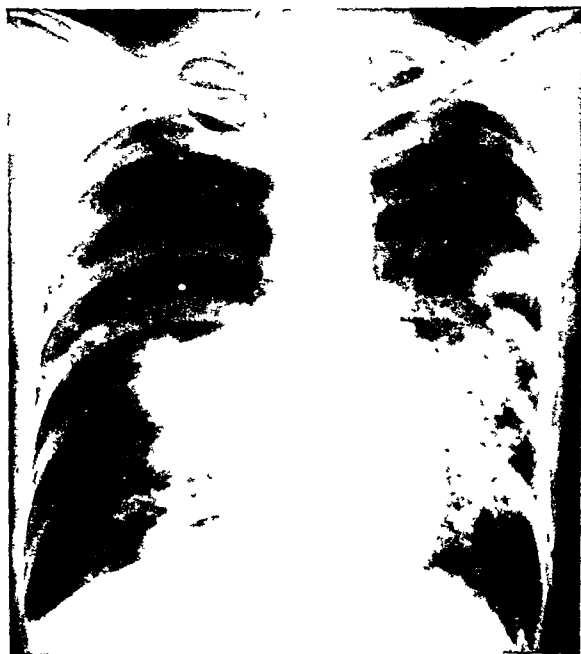


FIG. 15. Chronic tularemia. Reported through the courtesy of Lieutenant Colonel John L. Dixon. Chronic mediastinal adenopathy in a grocer, aged fifty-five, was subsequently followed by areas of massive consolidation involving the adjacent portions of the lung fields. This case of ulceroglandular tularemia followed a course similar to that described by Bihss and Berland.

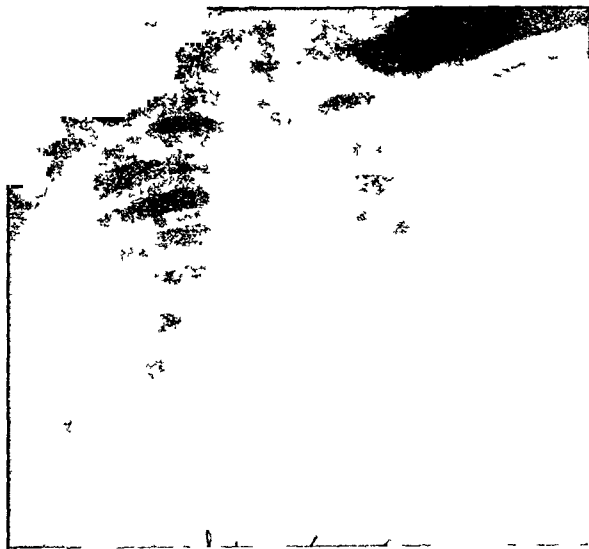


FIG. 16. Portable examination showing diffuse pulmonary lesions due to lipoid embolism in a soldier aged twenty-one. These densities appeared twenty-four hours after fracture of both bones of the left leg.

adenitis. A diagnosis of tularemia, based on clinical and laboratory findings, had been made at Walter Reed General Hospital. Biopsy was reported as positive for tularemia. Two years prior to admission the patient was seen by another consultant and the diagnosis was substantiated by confirmatory biopsy of a lymph node.

When first seen, the patient was an elderly, poorly nourished man, appearing chronically ill. He was ambulatory.

Roentgenograms revealed multiple coalescent lesions in both lung fields and bilateral hilar adenopathy. He was observed for six months, during which time the areas of consolidation noted initially showed resolution and new areas of involvement appeared. During this period there was slow regression of the epitrochlear and axillary lymphadenopathy. On several occasions during his terminal illness, transient pleural effusions were noted, but no cavitation could be demonstrated. Out of scientific curiosity one of the epitrochlear nodes was treated with irradiation and promptly resolved. The patient died six months after his initial examination and *B. tularensis* was recovered from both the lymph nodes and the pulmonary lesions.

Discussion. This is a rather unusual case in view of the chronicity of the symptoms,

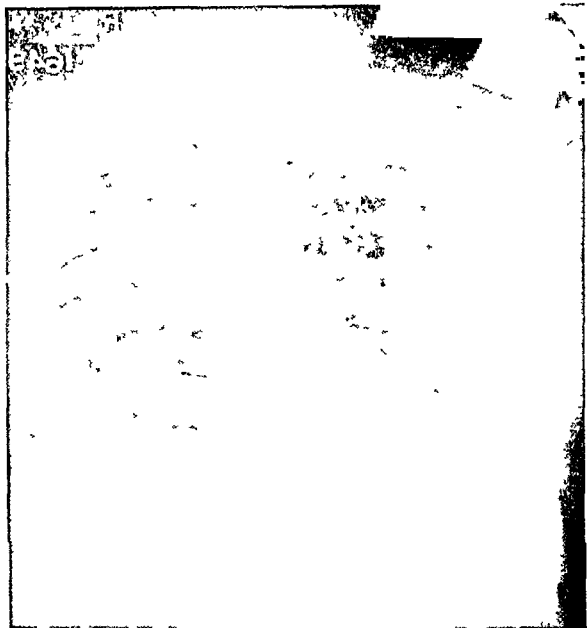


FIG. 17. Same case as Figure 16, showing clearing of the lung fields several days later. A residual lesion is now observed in the left costophrenic sulcus. This represents a pulmonary infarct arising from a bland thrombosis in the injured leg.

and is not to be confused with the pneumonia seen during the acute stage of tularemia.

CASE XIII. *Lipoid Embolism* (Fig. 16 and 17).

A sergeant, aged twenty-one, was admitted to Percy Jones General Hospital on June 8, 1945.

On July 18, 1945, he was injured while playing ball, incurring a fracture of the lower third of the left tibia and fibula. The fracture was reduced shortly afterwards under spinal anesthesia.

He was given sulfadiazine and sodium bicarbonate beginning on July 19. During the evening of July 19 he complained of mild shortness of breath. His respirations during the next few days often ranged between 30-40 per minute. During this time his temperature varied between 100 and 103.5°F. The pulse was proportional to the temperature.

On July 22 he became markedly dyspneic. Respirations were now 70 per minute, cyanosis was extreme, and the patient disoriented. The pupils were miotic. The chest showed hyporesonance, but no other findings. There was no evidence of pulmonary edema or increased venous pressure. A roentgenogram showed diffuse pulmonary densities. Laboratory examinations at this time showed a leukocyte count

of 12,200, with 81 per cent polymorphonuclears. Hg. was 11.5 grams, a drop of 4 grams when compared to a determination taken six weeks previously. NPN was 45 mg. per 100 cc. and CO₂ combining power was 69 per cent, both normal figures at this hospital. Electrocardiogram was normal.

When he was placed in an oxygen tent, his mental status improved markedly. Cyanosis was now minimal but tachypnea persisted at a rate of 60. Sulfadiazine and sodium bicarbonate were immediately discontinued and penicillin substituted. During the next few days he improved markedly. A non-productive cough was present. A specimen of urine showed no fat to be present. His fundi during this period contained hemorrhages with white centers, felt by the eye consultant to be embolic in origin. By July 28 respirations had dropped below 30 and temperature was normal. Chest films showed definite improvement in appearance of the lungs.

On July 29, while receiving penicillin, he suddenly developed pleuritic pain on the left, respirations rose to 50 and temperature to 103°F. During the next few days there was physical evidence of frank consolidation over the entire left lower lobe. The leukocyte count was again elevated and the roentgen picture was compatible with an infarct occupying the left costophrenic sulcus. There was no complaint of discomfort in either leg. The left leg could not be examined for evidence of venous thrombosis as it was in a cast.

He again improved within a few days, the respirations becoming normal by August 5. Low grade fever up to 99.5°F. persisted until September. Follow-up films showed disappearance of the diffuse pulmonary lesions within a few days after onset of pleuritic pain. The signs of consolidation at the left base disappeared within a week and were replaced by permanent signs suggestive of marked pleural thickening. The density of the left base became smaller during the next several months and the left diaphragm became elevated, flattened and fixed in its lateral portion. At the time of discharge, February 26, 1946, he had no complaints.

Discussion. In view of the relationship between the onset of pulmonary symptoms and fractures, as well as the drop in hemoglobin, the presence of cerebral symptoms

and the embolic phenomena visible in the fundi, a diagnosis of fat embolism is warranted. It is not felt that the reversible picture in the lungs, unassociated with other evidence of toxicity, could be accounted for by miliary necrosis due to sulfadiazine.

The second episode is of interest in that it occurred while the patient was receiving penicillin therapy. It is our opinion that pneumonia complicating fat embolism is unlikely. The characteristic location in the costophrenic sulcus suggests that a pulmonary infarct arising from a bland thrombus in the injured leg is a more than likely explanation.

The following case is of interest due to the widespread pulmonary changes, practically identical in appearance, but due to an entirely different cause.

CASE XIV. Löffler's Pneumonia (Transient Focal Pulmonary Edema) (Fig. 18 and 19).

Only a fragmentary history is available. The patient was admitted to the ward in critical condition. Dyspnea and cyanosis were extreme. He was placed in an oxygen tent and chemo-



FIG. 18. Löffler's pneumonia. This soldier, aged thirty-seven, was admitted in critical condition with a diagnosis of bronchopneumonia. White blood cell count was 14,800, with eosinophilia ranging between 17 and 39 per cent. Resolution of the pulmonary densities was accompanied by a marked diuresis.



FIG. 19. Löffler's pneumonia, same case as Figure 18. Roentgenogram made twenty-four hours later shows resolution of the process in both lung fields.

therapy was instituted. A diagnosis of bronchopneumonia was made. On admission there was a white blood cell count of 14,800. Three days later eosinophilia became apparent, ranging between 17 and 39 per cent. Roentgen study revealed diffuse bilateral densities obscuring the lung fields. Twenty-four hours later there was prompt resolution associated with a marked diuresis.

Discussion. One might inquire why two such seemingly unrelated disease entities as lipid embolism and Löffler's pneumonia should produce such similar roentgen manifestations. Perhaps the answer has been given by Jirka and Scuder¹⁷ who state: "Fat embolism is not a true embolism in the sense of permanent occlusion of the vessels, but is simply a retardation of blood flow through the capillary while the oil droplets become elongated and are slowly forced from the arteries to the veins."

However, some of the appearance in lipid embolism may be due to a local "toxic action," as suggested by Wilson and Salisbury,³² who feel that the chemical composition of fat may change in the blood stream following trauma, and that such changed fat may cause marked irritation of

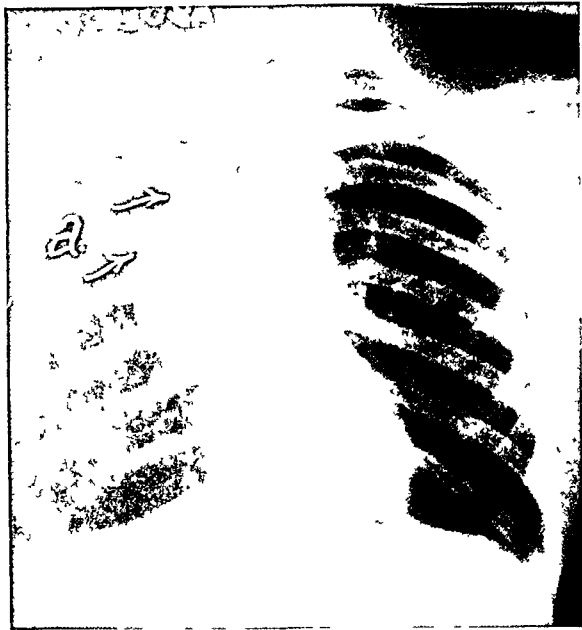


FIG. 20. Proved case of coccidioidomycosis showing enlargement of paratracheal and hilar lymph nodes at *a*. On the basis of the above appearance a diagnosis of Hodgkin's disease was erroneously made. Subsequently precipitin tests and biopsy proved the true nature of the disease.

the capillary endothelium. The causes of the "Succedanshatten," described by Löf-
fler, is unknown. Perhaps these transitory
densities, as suggested by Hansson,¹⁴ are
simply reflections of an internal exanthem.

CASE XV. *Coccidioidomycosis with Subcutaneous Abscesses and Diffuse Pulmonary Lesions* (Fig. 20 and 21).

This colored private, aged twenty-six, was admitted to Percy Jones General Hospital on July 29, 1945. During the summer and fall of 1944 he was stationed on the Arizona desert. In November, 1944, he noted shortness of breath, cough and expectoration of bloody sputum. Within a month a painful swelling appeared in the right supraclavicular area. Symptoms progressed and he rapidly lost weight and strength. He was hospitalized at a station hospital where roentgenograms showed hilar adenopathy and infiltrative changes in the right upper lung field. Tuberculin and coccidioidin skin tests were negative. He was transferred to a general hospital on March 8, 1945, where biopsy of the supraclavicular glands revealed the presence of numerous *Coccidioides* spherules. A complement fixation test for *Coccidioides immitis*, performed

by Dr. C. E. Smith of Stanford University, was at first positive in dilution of 1:32 and later of 1:256; the precipitin test was negative. He developed large painful subcutaneous abscesses over the region of the left ninth rib, each ilium and the spine of the left scapula. These abscesses ranged up to 10 cm. in diameter and were elevated 1 cm. above the surface of the skin. There was roentgen evidence of involvement of the bony structures underlying the abscesses.

On admission to Percy Jones General Hospital he was markedly emaciated and seriously ill. Chest films in August showed diffuse involvement of both lung fields. A blood count at this time showed marked anemia and eosinophilia as high as 19 per cent. *Coccidioides immitis* was obtained from the abscesses as well as the sputum. The patient was most uncomfortable due to pain in the region of the abscesses. Death occurred August 6, 1945.

Necropsy revealed the large abscesses to be filled with turbid brownish fluid. There was extensive involvement of the underlying bone. Skeletal structures involved included the ilia, sacrum, seventh, ninth and eleventh ribs on



FIG. 21. Same case as Figure 20. This illustration shows extension of the disease in the right lung field five months later. Note the diffuse pulmonary lesions with destruction of the right third rib at *a* and lytic lesions in scapula at *b*. Similar, less well marked changes were present in the left lung field, although not well shown in this illustration. At the time this roentgenogram was made the patient had large subcutaneous abscesses.

the left and the left coracoid process. The lungs showed complete replacement by innumerable miliary granular nodules. The right paratracheal lymph node involvement was continuous with that of the right supraclavicular region.

Discussion. The negative coccidioidin skin test in the face of dissemination was to be expected. Such dissemination is more apt to occur in Negroes. In the absence of positive bacteriological findings, diagnosis depends on positive complement fixation and precipitin tests. The subcutaneous abscesses were apparently caused by involvement of adjacent bone. Osseous structures near pressure points are commonly affected. Because of the right paratracheal lymphadenopathy, a diagnosis of Hodgkin's disease was made originally (see Fig. 20). A somewhat similar case, in which the diagnosis of lymphoblastoma was entertained because of right paratracheal adenopathy, follows.

CASE XVI. *Boeck's Sarcoid* (Fig. 22). A colored sergeant, aged thirty-one, developed rather persistent fatigue and right upper quadrant distress in June, 1942. Early in November, 1944, he became aware of marked bleeding from his gums and was admitted to the hospital. Physical examination at this time showed gingival bleeding, hemorrhagic retinitis and iridocyclitis, and marked thrombocytopenia, with platelet count as low as 20,000 were present. Chest roentgenogram revealed enlargement of the hilar lymph nodes. On November 8, shortly after admission, profuse gingival hemorrhage occurred. A few days later there was massive hematuria following which the patient became critically ill. He was given multiple blood transfusions. The platelet count soon rose and all signs of bleeding ceased.

A series of chest roentgenograms showed steadily increasing changes in the lung fields. A tuberculin test was negative. A cervical node was biopsied and on microscopic study the characteristic picture of Boeck's sarcoid was seen. He was subsequently discharged from the Army feeling well except for slight diminution in vision and a mild morning cough. The lung fields were still abnormal at the time of discharge.



FIG. 22. Boeck's sarcoid in a colored sergeant, aged thirty-one, with history of renal and gingival hemorrhages. Platelet count was found to be 20,000. Patient improved markedly after multiple blood transfusions. As the platelet count rose it became apparent that the original diagnosis of Hodgkin's disease with bone involvement was incorrect. Boeck's sarcoid was proved by cervical node biopsy.

Discussion. The fact that transient thrombocytopenia occurred is unusual. Nevertheless, we feel reasonably certain that this was a manifestation of Boeck's sarcoid. The progression of the pulmonary lesions with recession of the mediastinal adenopathy has been previously observed in sarcoid,⁴ and if present may aid in differential diagnosis from other mediastinal lesions.

CASE XVII. *Idiopathic Pulmonary Fibrosis* (Fig. 23 and 24). This corporal, aged twenty-nine, was admitted to Percy Jones General Hospital on September 21, 1943. Induction films, taken in 1942 and subsequently reviewed by us, were negative. There was no history of exposure to dusts or other noxious substances. He was stationed on the California desert from August, 1942, until March, 1943. In April, 1943, he developed persistent cough and expectoration and became increasingly dyspneic. Weight loss amounted to 40 pounds by the time of hospitalization.



FIG. 23 Idiopathic pulmonary fibrosis showing diffuse bilateral fibrotic changes and right-sided pneumothorax extending into the interlobe at *a*. The history was that of persistent cough, expectoration and marked weight loss in a corporal, aged twenty-nine. This case clinically showed close resemblance to the group described by Hamman and Rich.



FIG. 24. Same case as Figure 23. After an interval of forty-five days a left-sided hydropneumothorax is shown at *b*. Note the pleural changes at the left base, the obliteration of the left costophrenic sulcus and the pleural pericardial changes at the margin of the left ventricle.

On admission to the hospital he appeared chronically ill, showed mild clubbing of fingers and was dyspneic and cyanotic even at bedrest. The chest showed marked limitation of motion, diffuse rales and hyperresonance. Roentgenograms revealed a diffuse mottled infiltration throughout both lung fields and cyst-like areas in the right apex.

His course in the hospital was progressively retrogressive, with marked wasting and increasing dyspnea and cyanosis, requiring continuous oxygen therapy. The cough was productive of odorless, purulent, blood-streaked sputum, but practically no expectoration was present during the last two months of life. Low grade fever was present for a few weeks, after which he remained afebrile. Persistent tachycardia was noted. On several occasions spontaneous pneumothorax occurred. His subjective complaints were amazingly few. In January, 1944, mental confusion appeared, possibly due to anoxia and he died on January 28, with a clinical picture of terminal bronchopneumonia.

Laboratory Findings. Tuberculin and coccidioidin skin tests were negative, as were repeated examinations of the sputum for tubercle bacilli and fungi. Vital capacity on two occasions was 400 and 500 cc. respectively. The CO_2 combining power ranged between 93 and 105 vol. per cent. The venous oxygen content when under the oxygen tent was 14.3 vol. per cent and when out of the tent dropped to 4.4 vol. per cent. Corresponding figures for venous CO_2 content done simultaneously were 110 and 122 vol. per cent. The only other abnormalities of note among numerous laboratory procedures were a transient eosinophilia of 17 per cent, a sedimentation rate of between 42 and 57 mm. per hour, Hg. of 12 grams and electrocardiographic evidence of myocardial damage, but no right axis deviation.

Autopsy (by Major Sylvan Moolten) disclosed the presence of innumerable bullae of varying size between which was a widespread nodular granulomatous process made up of poorly formed epithelioid cells and containing numerous giant cells and a large amount of fibrous tissue.

Special search was made for tubercle bacilli and fungi, but none were found. Chemical analysis showed a normal silica content and no evidence of petroleum derivatives. A fat stain of the lung was negative, but the tracheobronchial lymph nodes, which showed the same granulomatous process as the lungs, revealed fat-

stained granules in the epithelioid cells. Small foci of granuloma containing fat were noted in the spleen and liver. The brain showed minimal changes probably resulting from anoxemia.

Discussion. It was Moolten's opinion that the granuloma resulted from the aspiration of a foreign oily or fat-like substance, which because of its volatile nature, was no longer evident in the lung itself. This opinion was concurred in by several other pathologists. Of great interest to us is the clinical resemblance of this case to the group described by Hamman and Rich¹¹ under the term "Acute Diffuse Interstitial Fibrosis of the Lungs."

CASE XVIII. Pulmonary Changes Associated with Cystic Disease of the Pancreas (Fig. 25). A child, aged twenty-two months, was admitted to Hartford Hospital on June 24, 1941. Birth had been two months premature. Since delivery she had had a protuberant abdomen and large frequent, non-fatty, odorless stools. Appetite was adequate and developmental history normal. Early in July, 1941, she was hospitalized because of continued cough. A diagnosis of celiac disease was made. As stool examinations suggested pancreatic insufficiency,

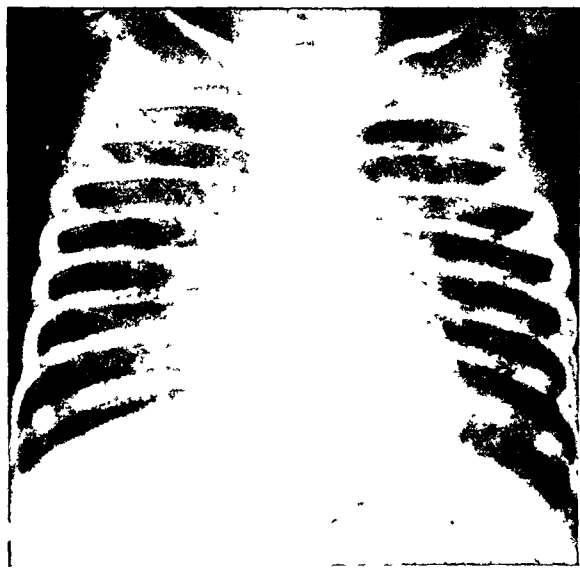


FIG. 25. Pulmonary changes in a child, aged twenty-two months, with history of celiac disease. The roentgen appearance is not specific, but the presence of ileus in association with roentgenographic findings of bronchitic disease should suggest the diagnosis.



FIG. 26. Incidental finding of multiple lime deposits in both lung fields. This private, aged twenty-four, had no symptoms referable to the chest. He was referred for treatment of vesical papilloma. Is such a picture due to healed tuberculosis, ascariasis, aspergillosis, or other healed mycotic infection, or to mitral disease with nodular bony formations? See text.

she was placed on a banana diet, which was followed by reduction in the number of stools to one daily.

Patient was discharged from the hospital on July 18, but was rehospitalized six days later because of continued fever, cough and irritability. On admission to the hospital she appeared acutely ill, emaciated, dehydrated and cyanotic. Rales were present over the lungs. There was marked distention of the abdomen. Moderate anemia and leukocytosis were noted. Roentgenogram of the chest disclosed extensive pulmonary changes.

The patient did not improve with chemotherapy and blood transfusions, and died on the seventh hospital day.

At autopsy congenital cystic fibrosis of the pancreas and multiple and bilateral suppurative focal areas of necrosis were found in the lungs.

Discussion. Baylin² has recently reviewed the roentgen literature dealing with this interesting type of bronchitic disease in

children. At necropsy the pancreas is found to be cystic, shrunken and filled with small and large epithelial-lined cysts. The few children who live longer than six months subsequently present signs and symptoms of celiac disease. A low vitamin A absorption curve is a constant finding. The most reliable diagnosis depends on assay of the pancreatic enzymes. The roentgenogram shows a symmetrical hilar and truncal prominence as shown in the present case. This homogeneous mottling in all lobes in an infant failing to gain after proper therapy should suggest vitamin A deficiency resulting from cystic disease of the pancreas, particularly if there is roentgen evidence of small bowel ileus.

SUMMARY

An effort has been made to review our clinical and roentgen experience with diffuse pulmonary lesions during the last three and one-half years.

A classification which has been found to be of distinct aid in evaluation of such lesions has been presented.

In these lesions experience shows that it is often hazardous to express an opinion of etiology solely on the basis of a single roentgen study. Even multiple examinations, which carry considerable weight, allowing as they do for evaluation of the factors of progression and retrogression, may not be absolutely diagnostic. However, in a vast majority of cases correct interpretation can be accomplished after careful correlation of both roentgenographic and clinical studies; in some few instances correct diagnoses will necessarily wait until necropsy.

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REFERENCES

1. AUSTRIAN, C. R., and BROWN, W. H., Miliary diseases of the lungs. *Am. Rev. Tuberc.*, 1942, 45, 751-755.
2. BAYLIN, G. J. Pulmonary changes in chronic cystic pancreatic disease. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1944, 52, 303-306.
3. BERG, G., and ZACHRISSON, C. G. Cystic-lungs of rare origin—tuberos sclerositis. *Acta radiol.*, 1941, 22, 425-436.
4. BERNSTEIN, S. S., and SUSSMAN, M. L. Thoracic manifestations of sarcoidosis. *Radiology*, 1945, 44, 37-43.
5. BIHSS, F. E., and BERLAND, H. I. Roentgenological manifestations of pleuropulmonary involvement in tularemia. *Radiology*, 1943, 41, 431-437.
6. CAFFEY, JOHN. *Pediatric X-Ray Diagnosis*. Year Book Publishers, Chicago, 1945, p. 333.
7. COLE, G. C. Structural changes in the lungs of drug addicts. *Arch. Int. Med.*, 1939, 64, 1039-1052.
8. CULVER, G. J. Miliary carcinosis of the lungs secondary to primary cancer of the gastrointestinal tract. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1945, 54, 474-482.
9. ELKELES, A., and GLYNN, L. E. Serial röntgenograms of chest in periarteritis nodosa as aid to diagnosis, with notes on pathology of pulmonary lesions. *Brit. J. Radiol.*, 1944, 17, 368-373.
10. GEEVER, E. F. Miliary calcification of the lung. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1943, 49, 777-782.
11. HAMMAN, L., and RICH, A. R. Acute diffuse interstitial fibrosis of lungs. *Bull. Johns Hopkins Hosp.*, 1944, 74, 177-212.
12. HAMPTON, A. O., PRANDONI, A. G., and KING, J. T. Pulmonary embolism from obscure sources. *Bull. Johns Hopkins Hosp.*, 1945, 76, 245-273.
13. HAMPTON, A. O., and CASTLEMAN, B. Correlation of postmortem chest teleroentgenograms with autopsy findings, with special reference to pulmonary embolism and infarction. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1940, 43, 305-326.
14. HANSSON, N. Transitory lung infiltration with eosinophilia. *Acta radiol.*, 1937, 18, 207-212.
15. HODES, P. J., and GRIFFITH, J. Q. Chest roentgenograms in polycythemia vera and polycythemia secondary to pulmonary arteriole-sclerosis. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1941, 46, 52-58.
16. HODES, P. J., and GROFF, R. A. Interstitial emphysema and pulmonary collapse complicating fractures of the skull. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1945, 54, 54-56.
17. JIRKA, F. J., and SCUDERI, C. S. Fat embolism; experimental study of value of roentgenograms of chest in diagnosis. *Arch. Surg.*, 1936, 33, 708-713.
18. KELLER, A. E., HILLSTROM, H. T., and GASS, R. S. The lungs of children with *Ascaris*; roentgenologic study. *J.A.M.A.*, 1932, 99, 1249-1251.
19. MURPHY, J. R., KRAININ, P., and GERSON, M. J.

- Scleroderma with pulmonary fibrosis. *J.A.M.A.*, 1941, 116, 499-501.
20. NESSA, C. B., and RIGLER, L. G. Roentgenological manifestations of pulmonary edema. *Radiology*, 1941, 37, 35-46.
21. OLSON, B. J., WRIGHT, W. H., and NOLAN, M. O. Epidemiological study of calcified pulmonary lesions in an Ohio county. *Pub. Health Rep.*, 1941, 56, 2105-2126.
22. PANCOAST, H. K., and PENDERGRASS, E. P. A review of pneumoconiosis; further roentgenological and pathological studies. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1931, 26, 556-614.
23. PAUL, L. W. Diseases of the mediastinum and associated conditions; refresher course. *Radiology*, 1943, 40, 10-41.
24. PEIRCE, C. B., and DIRKSE, P. F. Pulmonary pneumatocele (localized alveolar or lobular ectasia); certain considerations in cystic disease of lung. *Radiology*, 1937, 28, 651-667.
25. PENDERGRASS, E. P. Some considerations concerning the roentgen diagnosis of pneumoconiosis and silicosis. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 48, 571-594.
26. PENDERGRASS, E. P., and NEUHAUSER, E. B. D. Pleural lesions in hemophilia; report of case. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 48, 147-151.
27. PENDERGRASS, E. P., and WHITE, G. Pulmonary metastasis and pneumonitis following radiation therapy for cancer of the breast. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1943, 50, 491-498.
28. RABIN, C. B. Radiology of the chest. In: *Diagnostic Roentgenology*. Ross Golden, Editor. Thomas Nelson & Sons, New York, 1941, p. 189.
29. RANSOM, B. H. A newly recognized cause of pulmonary disease, *Ascaris lumbricoides*. *J.A.M.A.*, 1919, 73, 1210-1219.
30. RIGLER, L. G. *Outline of Roentgen Diagnosis*. J. B. Lippincott Co., Philadelphia, 1938, p. 94.
31. SANTE, L. R., and HUFFORD, C. E. Annular shadows of unusual type associated with acute pulmonary infection. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1943, 50, 719-732.
32. WILSON, J. J., and SALISBURY, C. J. Fat embolism in war surgery. *Brit. J. Surg.*, 1944, 31, 384-382.
33. WEISS, S., STEAD, E. A., WARREN, J. V., and BAILEY, O. T. Scleroderma heart disease. *Arch. Int. Med.*, 1943, 71, 749-776.
34. Nontuberculous pulmonary calcification. Editorial. *J.A.M.A.*, 1946, 130, 348.



BASAL ONSET OF REINFECTION TUBERCULOSIS

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ALTHOUGH Laennec¹² recognized the infrequency of mid lung and lower lobe tuberculosis, a characteristic apical onset with a downward extension has been considered pathognomonic of reinfection tuberculosis since his time. When contrasting basal and apical onsets certain similarities exist which should be recognized. The average age of this series of basal cases being 25.8 years and the female-male ratio 2.5:1 we have a group of individuals among whom subapical tuberculosis clinically and morphologically identical to basal tuberculosis may be found and the symptomology of which not infrequently indicates a short onset-diagnosis interval similar to that of reinfection tuberculosis with a basal onset.

CLINICAL MATERIAL

The clinical records including serial chest roentgenograms of 1,379 cases of reinfection pulmonary tuberculosis which had received sanatorium treatment and post sanatorium observation were used for this study. These patients were admitted to the sanatorium between 1930 and 1945 inclusive and represented predominantly industrial families with most nationalities included. The sanatorium admitted all ages with active tuberculosis. The Negro patient population averages approximately 4 per cent for the period.

Basal cases with apical lesions or apical adhesive pleurisy antedating the basal pulmonary pathology were not included. No case with coexisting basal onset and basal adhesive pleurisy was encountered. Moderate or extensive conglomerate calcification within any lung segment was considered a cause for excluding the case. Cases exhibiting roentgenographic evidence of active hilar lymphadenitis were not intentionally excluded and none occurred. An occasional case with a basal onset which

had extended to the mid or cephalad lung segments when first observed may have escaped detection even though a liberal interpretation was applied to avoid this error. When the mid lung or apical deposit equalled the basal deposit in quantity or extent of caseation or cavitation, the case was not considered as having had a basal onset. Accordingly, the definition of a basal onset of reinfection tuberculosis was formulated within these limits.

SUMMARY OF MATERIAL

Twenty-one, or 1.52 per cent, of this series had a characteristic basal onset of their tuberculosis. The average age of these basal cases was 25.8 years which was considerably less than the average age of the 1,379 reviewed. Fifteen were females and 6 males, a ratio of 2.5 to 1. Three were Negroes, or 14.28 per cent of the total. Various occupations were represented among the basal cases, including students. The contact date was accurately known by 6 and immediately preceded the onset of symptoms in all 6 instances. The onset-diagnosis interval averaged 30.61 days. Productive cough was the initial symptom in 10 cases. The expression, "acute cold" or "pneumonia" was not infrequent with these 10 cases. Weight loss was reported by all 21 cases, being only slight with 17. Fever existed previous to admission or was present on admission in 8 instances; dry pleurisy reported by 2 and hemoptysis by 7. Cough and expectoration during the course of the illness was slight with 10 and prominent with 11.

On admission 18 of the 21 basal cases received a moderately advanced classification and 3 far advanced. Twenty cases, or 95.25 per cent, exhibited cavitation. The original site of onset was right lower lobe in 3 cases, right middle in 5, and joint involvement of both the right middle and

lower lobes in 3, making a total of 11 right-sided cases as compared to 9 on the left side. Both lower lobes were simultaneously involved in one instance. Only the segment of the left upper lobe to which the anterior branch of the corresponding bronchus is distributed was considered as within the basal area. This is the most pendant portion of the upper lobe and may extend to the diaphragm anteriorly. This segment was involved 7 times, the left lower lobe twice. Joint involvement of both these segments did not occur.

The lesion was in all cases bronchopneumonic and disseminated in the segment involved. Caseation with a minimum amount of exudation was present in 11 cases while greater amounts of exudation characterized the lesion in 9 cases. Moderate conglomeration occurred in 3 cases and extensive conglomeration in 2 cases. One case exhibited productive changes in a right lower lobe lesion. This same patient exhibited a mixed exudative and caseous lesion of the left lower lobe. This was a twenty-three year old female whose onset diagnosis interval was 138 days. During the course of treatment cavity developed in the retrocardial space of the left lower lobe at which time the sputum first contained tubercle bacilli. Extensions existed on admission in 11 cases, the lung apices and subapical areas being involved in 8 cases. Extension to the contralateral lung apex occurred 3 times. Five cases had local or remote mixed exudative and caseous extensions while under treatment.

Resorption without end fibrosis or calcification followed treatment in 6 instances. Residual linear fibrosis was present in 8. Nineteen cases had sputa microscopically positive for tubercle bacilli. Extrapulmonary complications were confined to intestinal tuberculosis in one case and laryngeal in one. Hemoptysis occurred in 33.33 per cent of the cases.

DISCUSSION

Clinical analysis of these 21 cases of basal reinfectious tuberculosis revealed existence

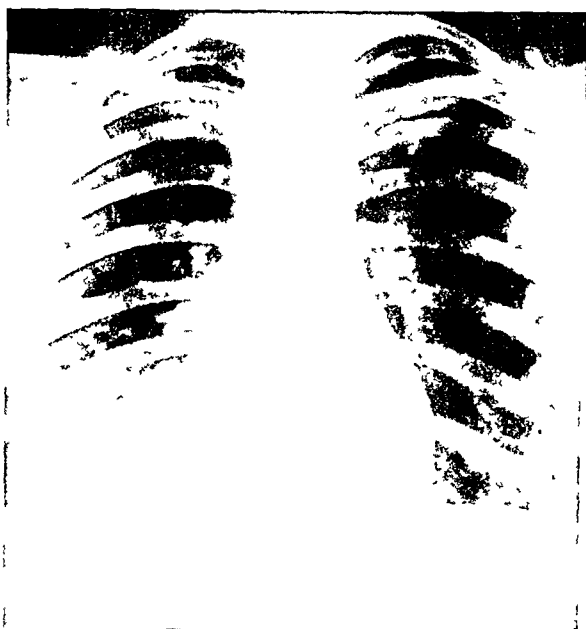


FIG. 1. Discretely outlined cavity without fluid level overlies the right diaphragm. In the absence of obstructive tuberculosis of the draining bronchus, the efficiency with which basal tuberculous cavities drain is remarkable.

of an abrupt symptomatic onset and a recent character of the lesion on the roentgenogram in all 21 instances. Similar acute onsets have been reported by other observers.^{4,17}

Clinical features confirming the acute character were an abrupt catarrhal onset in 47.6 per cent, a short onset-diagnosis interval during which all cases had advanced to a moderate or far advanced stage on diagnosis and the insignificant weight loss made by each case, a circumstance which could only be accounted for by a period of focal activity insufficiently long to produce nutritional disturbances. The rapid appearance of cavity reflected the instability of caseous deposit in the more freely mobile lung base.

Three means by which basal reinfection is acquired have been advanced: massive inhalation,⁷ rupture of a tuberculous lymph gland into a bronchus,^{3,5} and direct extension from the hilum.³ The observations of Ross¹⁷ support the inhalation theory, which for all purposes seems the most plausible. He found 18.26 per cent of 60 tuberculous



FIG. 2. Typical caseous bronchopneumonic tuberculosis of the right middle lobe is here demonstrated. Separation of all lobes followed institution of artificial pneumothorax. Fibrosis and resorption of deposit with closure of cavity occurred. Atelectasis of the lobe did not develop.

hospital nurses of training age to have had a basal onset of their tuberculosis which developed soon after graduation. Proponents of the inhalation theory have pointed to the greater frequency of right side involvement^{4,15} and suggested that the straight right main stem bronchus accounted for this. Explanations for a greater right side incidence which in this series was only slight and for tuberculosis being selective for certain lung segments remain hypothetical. Due to a slight disproportion in the size of the two lungs, the total minute tidal air in health is greater on the right than the left which should account in part for a greater right side incidence. Observation supports the theory that tuberculosis is selective for the less well ventilated segments. Segmental distribution of the initial lesion in this series of basal cases supports this theory. The right middle lobe was involved 8 times and the left lower lingual

segment 7 times as contrasted with involvement of the right lower lobe 6 times and the left lower lobe 3 times. This numerical distribution reminds one of the frequent right middle lobe and left lingual extensions from apical cavitation.

Diminished efficiency of bronchial drainage coexisting with and being the result of reduced ventilatory efficiency influences the localization of tuberculosis. The lengthening and shortening process of the bronchi during respiration¹³ undoubtedly functions jointly with the ciliated epithelia to accomplish this cleaning process. Pinner¹⁴ suggested the existence of this influence. Delayed removal of inhaled bacilli from the bronchial mucosa of any lung segment provides greater time for them to be carried into the lung structure by migrating leukocytes. This reasoning may in part explain the greater frequency of apical tuberculosis where the thorax is less expansible¹¹ and the less frequency of lower lobe tuberculosis where maximum expansion produces greater bronchial mobility. One doing pulmonary lipiodol injections under the roentgenoscope is impressed by this variation. Pointing to the promptness with which the right middle lobe or the left lower lingual segment becomes atelectatic with the appearance of excess secretions, strong support for this opinion is found in one's own clinical experience. In the absence of factual data this theory of diminished efficiency of bronchial drainage combined with that of Dock,⁶ which presupposes the existence of ineffective arterial circulation of the cephalad third of the lungs in the standing or sitting position, offers the most plausible explanation for apical localization being numerically the more frequent. Indications are that infection was in this series exogenous and inhaled. To support this opinion some significance should be attached to the existence of known contact immediately preceding onset of symptoms in 28.5 per cent of the cases.

Presuming that the source of infection was bronchial inhalation in each instance,

the morphological characteristics as seen on roentgen examination should have been common to each of the 21 cases. In a general way this similarity existed. These characteristics conformed to those of bronchopneumonic tuberculosis-multiple lobular, bronchopneumonic areas disseminated throughout the lung segments and with a central area of greater concentration at which cavity not infrequently existed. These isolated areas were, in the typical cases, about the same size and therefore the same age. These morphological characteristics indicated that an overextended first infection had not been confused with reinfection tuberculosis in any instance.

The original lesion was not in any case confined to the earliest lobular pneumonic infiltrate common among adolescents, young females and Negroes² but had progressed to a symptomatic disseminated bronchopneumonic tuberculosis⁸ in all. The conclusion that exudation is a whole or major part of the structural concept of the earliest roentgen-ray infiltrate or of the subsequent expanded phase does not have autopsy support. Caseation is an attendant circumstance in all so-called exudative tuberculosis.¹ Remote extensions in these basal cases provided the best roentgenological link between the earliest infiltrate and subsequent events. These extensions were soft circumscribed infiltrates which when translated into comparative autopsy observations, consisted of a central area of caseous necrosis with collateral exudate. Beginning with the early and probably multiple infiltrates the whole evolution of reinfection tuberculosis with a basal onset through overextension, conglomeration and cavitation is not unlike tuberculosis of any lung segment except in the momentum of this metamorphosis. Genetic factors, lowered nitrogen and calcium retention of teen aged females,¹⁰ exhaustion, inadequate nutrition, reduced immunity, greater mobility of the lung base, these control this momentum and dictate the proportions of exudation, caseation and fibrosis.

A complete explanation for the female-

male ratio of 2.5:1 was not found. Similar ratios without complete explanation have been reported by other observers.^{3,16,18,19}

Complications were infrequent due no doubt to the short duration of focal activity and to the prompt and frequent use of artificial pneumothorax. The absence of adhesive pleurisy, a reflection of the short onset-diagnosis interval, uniformly permitted the establishment of pneumothorax without difficulty. Clinical symptoms indicated the presence of tuberculous bronchitis in a single instance. This was confirmed by bronchoscopy and recovery followed pneumothorax therapy. Another basal case with tuberculous bronchitis, not reported in this series and now on routine rest combined with phrenicectomy, is recovering. The single case exhibiting laryngeal tuberculosis was a twenty-two year old female whose pulmonary lesion consisted of extensive conglomeration approaching consolidation of the right lower and middle lobes with multiple cavitation. This patient's onset-diagnosis interval was only sixty days.

TREATMENT AND RESULTS

Increased pathogenesis of reinfection tuberculosis with a basal onset seems fully established, and coming as it more exactly does to females and during the early productive and reproductive period, presents exigencies which call for prompt and specific measures. Early active measures should be taken to combat the tendency a large proportion of these cases have to caseate and progress instead of fibrose and retrogress. Pneumothorax should be immediately instituted^{4,17} if cavitation exists. Cases without demonstrable cavity or substantial conglomeration may be given a short trial period of bed rest. In the instance of basal tuberculosis as in tuberculosis of other lung segments a waiting period for fibrosis to set in or caseation to excavate before pneumothorax is established should not be considered unless large subpleural cavities or extensive subpleural caseous conglomeration exists in which instances

pneumothorax is contraindicated. Exudation and caseation are more inclined to undergo fibrous replacement and resorption in the presence of pneumothorax. Pneumothorax should be hypotensive as a safeguard against atelectasis of the right middle lobe and peripheral basal portions of the lower lobes. Phrenicectomy combined with pneumothorax may be desirable for right side cases not responding to pneumothorax alone. Thoracoplasty is the most undesirable means of treating basal tuberculosis. Two of the 18 cases remaining in the sanatorium for adequate treatment received phrenicectomy and bed rest, 5 bed rest alone and 11 artificial pneumothorax and bed rest.

Events subsequent to admission to the sanatorium were not unlike those of apical tuberculosis.⁴ The prognosis seemed invariably good if the far advanced stage had not been reached and immediate adequate treatment was given. This conclusion was not reached by others.^{4,18} Ross¹⁷ and Gordon⁹ considered the prognosis good.

Of the treated group, 88.8 per cent recovered and were known to have been well on the average of 72.3 months after diagnosis. When treated by pneumothorax the recovery period averaged 85.2 months, by rest routine 72.5 months. The maximum period of recovery was 185 months. This patient received pneumothorax combined with phrenicectomy.

CONCLUSION

Twenty-one, or 1.52 per cent, of 1,379 known cases of tuberculosis were found to have had a characteristic basal onset of their disease. A short onset diagnosis interval averaging 30.61 days, extension of the lesion to a moderate or far advanced stage in all cases during this interval and roentgenographic characteristics indicated that reinfection tuberculosis with a basal onset, although having a counterpart in subapical tuberculosis, should be classified as an acute and progressive form of tuberculosis. The average age of the twenty-one

cases was 25.8 years, the female-male ratio 2.5:1. Early active treatment is indicated. Pneumothorax therapy is the preferable means of treatment. The prognosis is good, 88.8 per cent of this series having recovered and were known to have been well on an average of 72.3 months after diagnosis.

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REFERENCES

1. AMBERSON, J. B., JR. Resolution process in pulmonary tuberculosis. *Tr. A. Am. Physicians*, 1935, 50, 37-47.
2. AMBERSON, J. B., JR. Features of early pulmonary infiltration. *California & West. Med.*, 1942, 57, 25-27.
3. ANDOSCA, J. B., and FOLEY, J. A. Basal tuberculosis. *J. Thoracic Surg.*, 1943, 12, 259-266.
4. BUSBY, L. F. Basal tuberculosis. *Am. Rev. Tuberc.*, 1939, 40, 692-703.
5. COLTON, W. A. Basal lesions in pulmonary tuberculosis, with report of 7 cases. *U. S. Vet. Bur. M. Bull.*, 1928, 4, 503-511.
6. DOCK, W. Apical localization of phthisis. *Am. Rev. Tuberc.*, 1946, 53, 297-305.
7. DUNHAM, K., and NORTON, V. V. Basal tuberculosis. *J.A.M.A.*, 1927, 89, 1573-1575.
8. FISHBERG, M. Infraclavicular tuberculous infiltrations. *Am. Rev. Tuberc.*, 1928, 17, 1-21.
9. GORDON, B. Basal pulmonary tuberculosis. *Internat. Clin.*, 1936, 1, 67-77.
10. JOHNSTON, J. A. Factors influencing retention of nitrogen and calcium in period of growth. *Am. J. Dis. Child.*, 1940, 59, 287-309.
11. KEITH, A. Further Advances in Physiology. L. Hill, London, 1909.
12. LAENNEC, R. T. M. A Treatise on Diseases of the Chest and Mediate Auscultation. Translation by J. Forbs. 1925, 4, 265.
13. MACKLIN, C. C. Dynamic bronchial tree. *Am. Rev. Tuberc.*, 1932, 25, 393-417.
14. PINNER, M. Pulmonary Tuberculosis in the Adult. Charles C Thomas, Springfield, Illinois, p. 389.
15. REISNER, D. Pulmonary tuberculosis of the lower lobe. *Arch. Int. Med.*, 1935, 56, 258-280.
16. ROMENDICK, S. S., FRIEDMAN, B., and SCHWARTZ, H. F. Lower lung field tuberculosis. *Dis. of Chest*, 1944, 10, 481-488.
17. ROSS, E. L. Tuberculosis in nurses. *Canad. M.A.J.*, 1930, 22, 347-354.
18. VISWANATHAN, R. Tuberculosis of the lower lobe. *Brit. M. J.*, 1936, 2, 1300-1302.
19. WEIDMAN, W. H., and CAMPBELL, H. B. Lower lobe tuberculosis. *Am. Rev. Tuberc.*, 1937, 36, 525-541.

THE CRATER IN UNCOMPLICATED DUODENAL ULCER

ITS SIGNIFICANCE IN DIAGNOSIS AND TREATMENT*

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IN THE diagnosis of duodenal ulcer, the roentgenologic demonstration of crater is the most important single diagnostic sign for, by definition, the terms crater, ulcer, and open sore are synonymous. In the strictest sense, therefore, the only direct roentgenologic sign of ulcer is the crater. Deformity of the duodenal bulb, long used as a sign for ulcer, has certain limitations, even though experience over many years has proved it to be highly accurate. Deformity usually persists after an ulcer heals and therefore cannot be used to determine if an ulcer is active or not. Deformity may be caused by other processes such as adhesions or neoplasm. It is claimed that deformity may be produced by spasm, stimulated by extraneous stimuli. Also deformity may not be present in a significant number of patients suffering from duodenal ulcer. In the latter instance crater is the sole evidence.¹

Crater cannot be relied upon to detect all ulcers, or to determine activity in all instances. A survey of the literature indicates that those who use the filming fluoroscope routinely in examinations of the duodenum fail to demonstrate the crater in from 10 to 50 per cent of the patients having symptoms of activity. In my experience, the percentage is about 35 or 283 of 809 patients having clinically active untreated ulcers.

In the patients having clinically active ulcers, collaborative evidence was obtained roentgenologically by demonstrating a deformity of the duodenal bulb in 231 of the 283 cases, or 81 per cent. In 42 of the remaining 52 instances, the duodenum was normal. The possibility that an ulcer lay in the stomach was reduced to a minimum by

the fact that no crater was seen at gastroscopic examination. In the 10 remaining cases, a diagnosis of duodenitis was made. In the entire group of 809 cases the diagnosis of normal was returned in only the 42 cases, or approximately 6 per cent.

The use of clinical evidence to determine whether the duodenal ulcer is active or not is open to criticism. It is not possible to obtain a representative group with pathologic controls and no satisfactory duodenoscope has yet been devised. The roentgenologist therefore relies on the judgment of the clinician except in those instances in which crater was demonstrated. In these instances the ulcer was considered to be active regardless of the clinical symptoms and signs.

Since crater is the most important single sign of active ulcer it becomes the most important sign to follow during the course of medical management. As management proceeds, and the ulcer heals, the crater decreases in size and eventually disappears.

Deformity may decrease, remain stationary, or increase with resulting stenosis during medical management. In most instances the deformity of the bulb changes not at all or only slightly as the crater disappears. Changes in motor phenomena sometimes referred to as "irritability" and "local tenderness" are not reliable criteria to judge healing. They are encountered in patients in whom there is no reason to suspect ulcer and are not encountered in all patients in whom crater is seen or in all patients having pronounced clinical evidence of ulcer.

Changes occurring in a crater during the course of medical management are used by some clinicians as aids to control treatment

* Presented at the Forty-seventh Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 17-20, 1946.

or to evaluate new methods of treatment.³ Figure 1 illustrates the variations that occur in the rate of healing in a group of patients treated in the hospital by rigidly controlled regimen of milk and cream, powders, frequent feedings and belladonna and aspirations.

When a group of patients, each having an ulcer are observed periodically, certain interesting phenomena occur. For instance, large crater may appear rapidly and be accompanied by distress. In one instance, in which a crater appeared in a ten day interval between two examinations, the patient had not been following his diet. In another instance, the crater was present and the patient had no symptoms. The patient claimed to have maintained his diet. Apparently the "ambulatory" regimen outlined for the patient was sufficient to con-

trol the symptoms but not influence the crater. Evidence that an ulcer can be present in patients without symptoms is found in the so-called "silent" hemorrhage.

Some ulcers may heal and leave no apparent vestige of their previous existence. This usually occurs in a duodenal bulb which is not deformed or is only slightly deformed and in which crater is the only definite evidence. In a few of these bulbs radiating folds can be demonstrated on roentgenograms made with careful compression.¹

In patients with pronounced deformity and with crater, the deformity changes only slightly as the crater disappears. The changes may be sufficient, however, to relieve obstruction in those cases in which edema or muscular contraction subsides, or they may produce obstruction some time

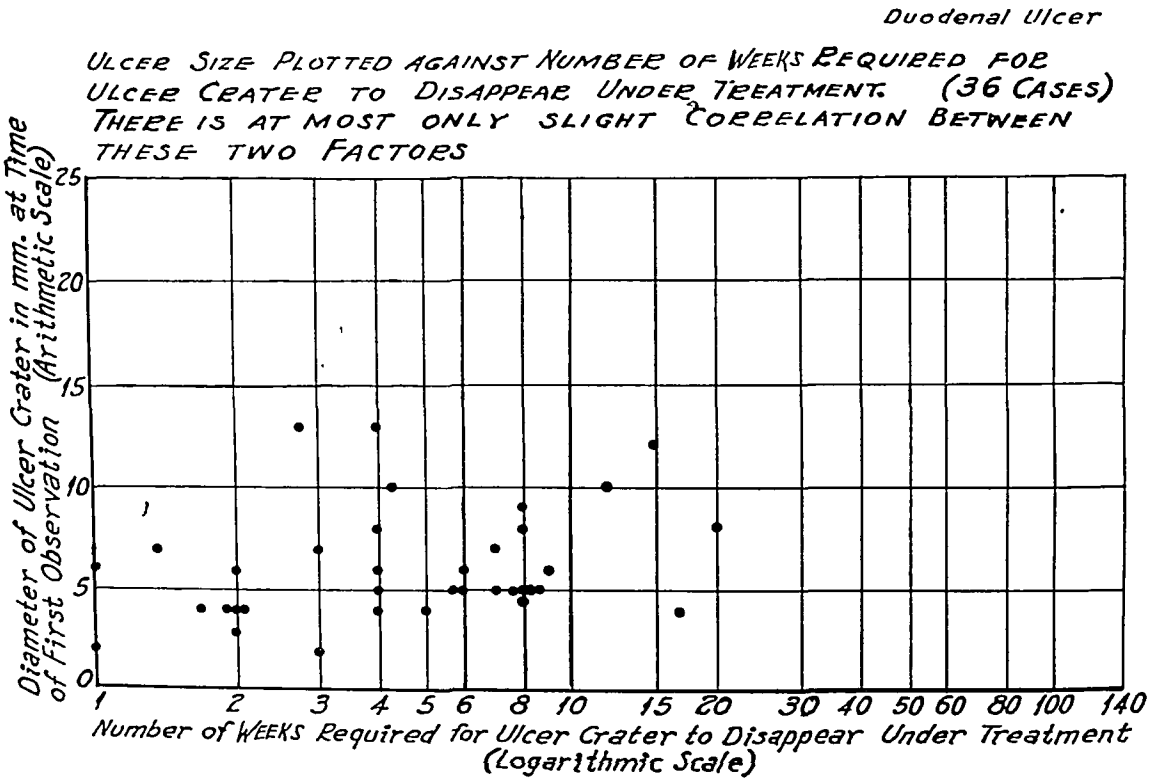


FIG. 1.* Sizes of ulcer craters in the duodenum plotted against number of weeks for crater to disappear after treatment in the hospital.

* In a previous publication¹ the sizes of craters were, by error, plotted against days instead of weeks required for healing. When the error is corrected and the average healing time calculated, a figure of about forty-five days is obtained. This is comparable to forty days reported for gastric ulcer by Ohnell² and thirty-seven days reported for duodenal ulcer by Cummins, Grossman and Ivy.³

later as the scar tissue laid down with healing contracts. The deformity does not change appreciably in most cases even though the ulcer undergoes exacerbations and remissions. Apparently the deformity appears soon after the patient experiences his first symptoms and remains much the same with only slight variations throughout most of the life of the ulcer. I have not been able to find a relationship between the age of the crater, the duration of symptoms and the amount of deformity. Patients with histories of only six or seven weeks' duration had marked deformities and patients with histories dating back twenty years have not had deformity, but had prominent craters. I have not yet been able to obtain evidence of a marked change occurring in a duodenum during healing or with recurrence even though some patients were examined periodically for eight years.

Most recurrent ulcers occur at the site of a previously demonstrated crater. This is at variance with pathologic examinations

in which multiple ulcer scars are found in both the duodenum and stomach. I have no satisfactory explanation for this discrepancy.

SUMMARY

1. The crater is the most reliable roentgenologic evidence that a duodenal ulcer is active.
2. Periodic observations of a crater in a duodenal ulcer is a valuable aid in judging the effect of medical management.*

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REFERENCES

1. TEMPLETON F. E. X-Ray Examination of the Stomach. University of Chicago Press, 1944.
2. OHNELL, H. Interne Behandlung bei ulcus ventriculi mit röntgenologischer Nyche. *Acta med. Scandinav.*, 1920, 52, 1.
3. CUMMINS, G. M., GROSSMAN, M. I., and IVY, A. C. Study of time of healing of peptic ulcer in a series of sixty-nine cases of duodenal and gastric craters. *Gastroenterology*, 1946, 7, 20-37.

* For discussion see page 103.



POST BULBAR ULCER OF THE DUODENUM*

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ULCER craters in the duodenum are not commonly found distal to the bulb. Since many of these cases show a high incidence of hemorrhage, often of the massive type, it is important that a careful search be made for them in the examination of the upper gastrointestinal tract. Standard references on roentgen diagnosis of lesions of the duodenum have not emphasized the roentgenographic findings in the presence of this lesion. It is the purpose of this paper to review the roentgenographic findings; also to stress the aid of placing the patient in special and unusual positions when films are taken to disclose the presence of a post bulbar ulcer.

LITERATURE

The roentgenographic findings have been described in case reports by American,^{3,25} Italian,^{8,20,27,32,36} French,^{4,10,12} and Swedish³⁵ authors. That the lesion is overlooked at times is emphasized in a report by Graham¹¹ of Toronto on "the surgeon's problem in duodenal ulcer." Graham encountered 17 cases with penetrating ulcer of the descending limb of the duodenum. (Severe hemorrhage into the gastrointestinal tract manifested by hematemesis or melena or both and the frequency of pain extending to the back were the prominent clinical findings.) The ulcer crater was not seen in the roentgen examination of these cases. In one case, the patient had three exploratory laparotomies before the lesion was found. Because of the apparent diagnostic difficulties of the post bulbar ulcer lesions, Graham grouped them under the title of "duodenal ulcer occulta."

One of the first complete statistical studies of diseases of the duodenum, and perhaps the most frequently quoted, is that by Perry and Shaw²² on the analysis

of 17,652 autopsies done at Guy's Hospital between 1826 and 1892. Perry and Shaw report 18 out of 141 ulcers of the duodenum, more than 12 per cent, were found distal to the "first portion." In subsequent reports upon necropsy material by other authors,^{23,29} the incidence of post bulbar ulcer has ranged from 5 to 20 per cent.

The incidence of post bulbar ulcer, as determined from surgical exploration, is extremely difficult to evaluate. In the surgical treatment of duodenal ulcer, a subtotal gastrectomy is usually done. In more recent years the ulcer crater in the duodenum is frequently not disturbed since the treatment is not intended to be a direct, immediate eradication of the ulcer. In cases of an acute perforation the ulcer is often treated by closing the perforation without exploring the remainder of the duodenum. In the first 25 years of the century, however, a direct attack upon the duodenal ulcer was the common procedure and the lesion was excised or cauterized. This afforded an opportunity to observe the interior of the duodenum in the living.

Commenting upon the pathologic data obtained from ulcers excised from the anterior wall of the duodenum, Mayo¹⁶ (1913) says: "We had excised several ulcers of the anterior duodenal wall before our attention was attracted to the occasional co-existence of an ulcer on the posterior wall . . ." In the same article Mayo describes the two types of ulcer craters found in the duodenum, the superficial mucosal type and the penetrating, so-called gastric type with a calloused base. Concerning the superficial type, Mayo says: "Ulcers on the anterior wall of the duodenum, without obstruction and callus, upon excision will often show a defect scarcely greater than a dimple." Regarding

* From the Departments of Radiology of the Presbyterian Hospital and the College of Physicians and Surgeons, Columbia University, New York. Presented at the Forty-seventh Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 17-20, 1946.

the other type of ulcer Mayo continues: "Ulcers of the posterior wall of the duodenum present the same characteristics as those of the stomach, that is, a clean-cut, punched-out area, attached closely to the pancreas and usually completely perforating the duodenum." At a later date, Judd¹³ (1921), writing on the pathologic conditions of the duodenum, says: "From 1906 to 1921, 4901 operations for ulcer of the duodenum were performed in the Mayo Clinic." "A posterior ulcer was found in nearly half of the cases in which we excised an ulcer from the anterior surface." "Also, since a search has been made for ulcer on the deep surface several inches from the pylorus many have been found at this point." Judd describes two types of ulcers found in the duodenum, namely, the one resembling the ulcer found in the stomach and the "submucous ulcer" without a crater. Judd uses the terms "duodenitis" and "submucous ulcer" synonymously. In the analysis of a series of 531 cases of duodenal ulcer, which he personally had operated upon, Sir Berkeley Moynihan¹⁹ (1923) does not discuss the ulcers located distal to the bulb but in a book on duodenal ulcer published in 1910,¹⁸ he states that about 5 per cent are found more than 2 inches distal to the pylorus.

Writing about the roentgen observations on the duodenum with special reference to lesions beyond the first portion, Case⁷ in 1916 reported that he had not found an ulcer distal to the bulb at that time. Case predicted that they would be found and suggested a technique of examination, with the patient lying on the right side, which might show them. In a report on the roentgen diagnosis of peptic ulcer in 1918, Baetjer and Friedenwald¹ analyze 743 cases. In this group of cases, 68 duodenal ulcers were operated on. However, no mention was made of an ulcer distal to the bulb. Carman⁶ in 1920, writing about the localization of peptic ulcer by the roentgen ray, estimates that about 5 per cent are found distal to the bulb. Sutherland³¹ (1927), in a comparison of the roentgenolog-

ic and histopathologic findings in duodenal ulcer, estimates that about 95 per cent are found within the first 3 cm. of the bulb. At the radiological section of the Southern Medical Society meeting in 1933, Robinson²⁵ reported 10 cases of surgically verified post bulbar ulcers of the duodenum. He described, and illustrated with roentgenograms, the roentgen signs, but did not give an estimate of the incidence of the lesion.

The actual incidence of post bulbar ulcer of the duodenum is then quite undetermined. In routine necropsy material the lesion is found in 5 to 20 per cent of cases with ulcers of the duodenum. Reports on surgical material suggest that it might be found more often than the oft-quoted 5 per cent if the exact anatomical location is noted and the posterior wall of the duodenum is examined. The incidence reported in roentgenological statistical studies^{1,17,21} is low, and is not mentioned in some reports. The possibility of post bulbar ulcer should be considered in those cases which show evidence of deformity, irritability and distorted mucosal pattern of any portion of the proximal half of the duodenal loop.

ANATOMY

The anatomical features of the duodenal loop are variable in different people. For the sake of clarity in discussion it is well to specify the boundaries of its subdivisions. The proximal extremity begins on the distal side of the pylorus and the distal extremity ends at the ligament of Treitz, where it is continuous with the jejunum. These two anatomical landmarks, the pylorus and the duodenojejunal flexure, are usually fairly well seen in roentgenograms of the barium-filled duodenum. Likewise they are not too difficult to recognize by inspection at a surgical operation.

The subdivisions of the duodenum are often not too well stated in terms of exact boundaries. Sometimes it is not possible to be certain about the exact limits from external inspection at the operating table or by the inspection of a roentgenogram.

In the presence of disease the organ can be distorted in such a manner that the anatomical features are not sharply delimited. In such cases it might be necessary, in description, to refer to a lesion as being in the area adjacent to the junction of subdivisions. For greater accuracy in localiza-

is sometimes given terms which are meant to be synonymous but actually are ambiguous. For example, the terms "first portion," "bulb," "cap," and "pars superior" are found to be used synonymously. Actually the bulb is a subdivision of the pars superior (Fig. 1).

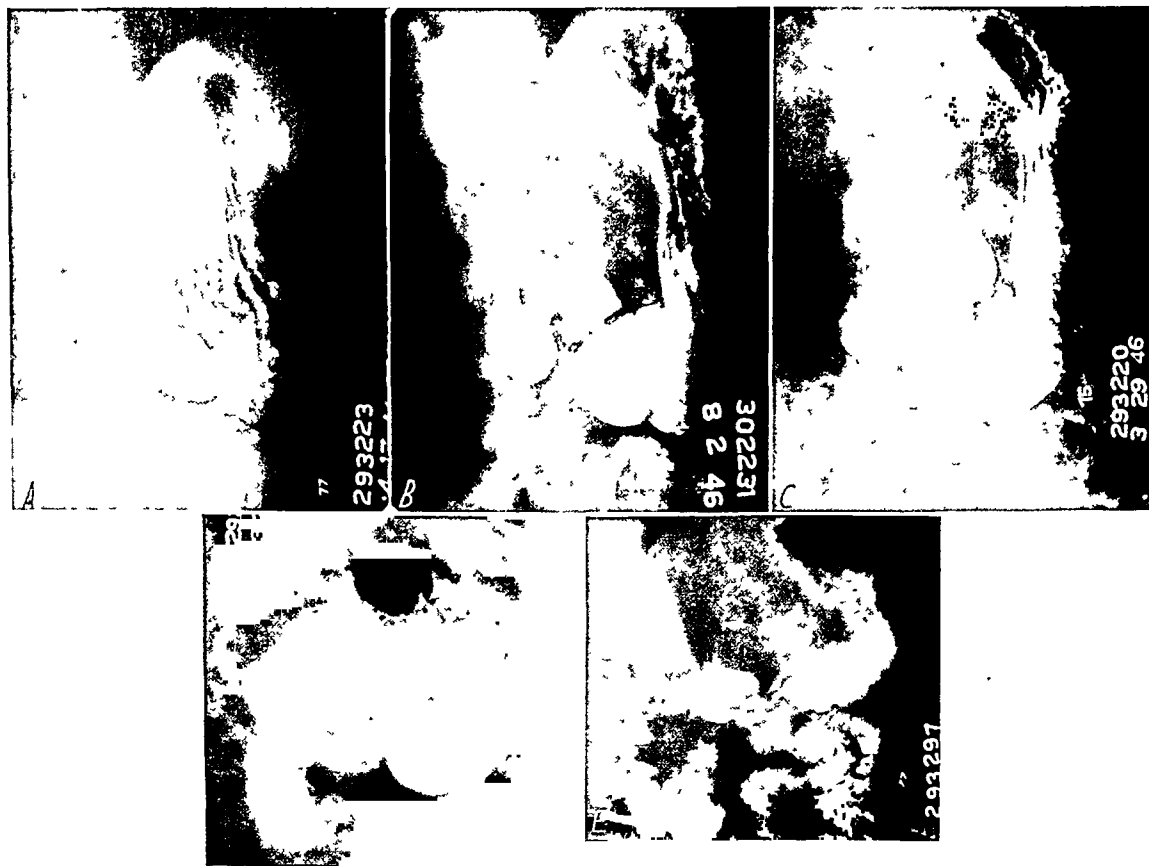


FIG. 1. Anatomical variation in the normal duodenum. Five cases (reading from left to right) showing the different appearances of the pars superior. In *A*, the bulbous proximal extremity is seen to extend about five-eighths the distance from the pylorus to the midportion of the genu superius. *B* shows a redundant loop between the apex of the bulb and the genu superius. This is sometimes called a hammock type. *C* shows the pars superior to be about as long as seen in *B*, and the bulb is not more than one-third the length of the pars superior. However, no redundant loop is present. *D*, below, shows the bulb apex to extend to very near the flexure. In *E*, the large circular folds of the mucosa are seen in close proximity to the pylorus. The junction of the pars superior with the descending limb often appears narrower than the adjacent portions.

tion, and for statistical purposes, it would seem advisable, when possible, to use the anatomical term of the smallest subdivision.

In the anatomy textbooks, and in roentgenographic literature, the duodenum is divided into the pars superior, the descending limb, the pars inferior, and the ascending limb. Unfortunately, the pars superior

The boundaries of the bulbous proximal extremity of the duodenum has been described by Cole⁹ as extending from the pylorus to the first Kerkring ring (valvula conniventes). It is reported to average about 5 cm. in length.^{2,18} However, its length and size are quite variable. The length of the pars superior, including the bulb, is reported to average about 8 cm.²⁴

Or, to state it another way, the bulb is, in the average case, about five-eighths the length of the pars superior. In some cases, however, the length of the bulb is not more than one-fifth the length of the pars superior. The distal extremity of the pars superior is the flexure, the genu superius,

(flexure), in the proximal portion of the descending duodenum.

Ulcer craters distal to the bulb are seen best in exaggerated oblique views. The patient is placed on the right side in a horizontal posture and, under fluoroscopic observation, rotated slightly toward a

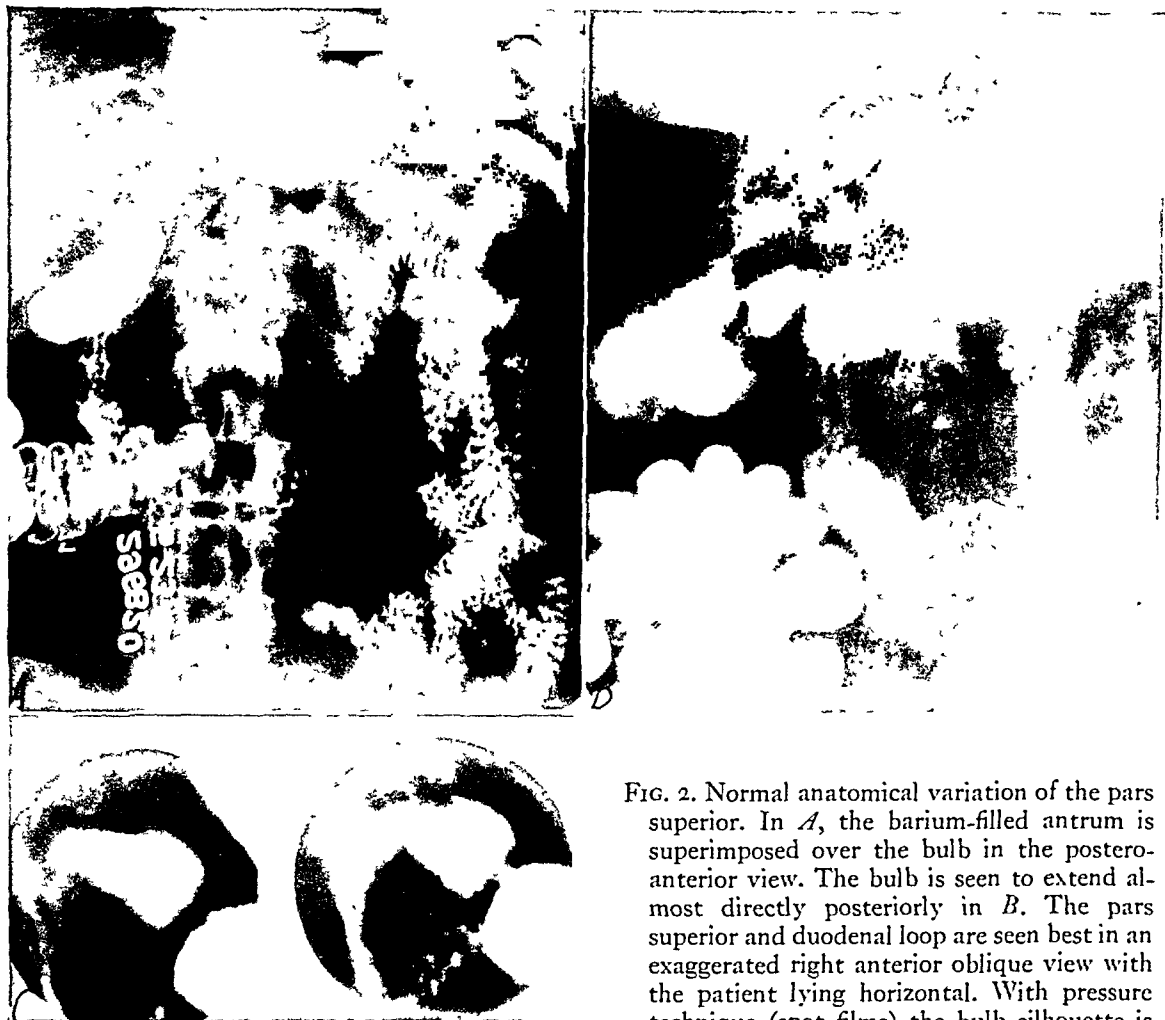


FIG. 2. Normal anatomical variation of the pars superior. In *A*, the barium-filled antrum is superimposed over the bulb in the postero-anterior view. The bulb is seen to extend almost directly posteriorly in *B*. The pars superior and duodenal loop are seen best in an exaggerated right anterior oblique view with the patient lying horizontal. With pressure technique (spot films) the bulb silhouette is

well shown in *C*, but in this projection the pars superior distal to the bulb is foreshortened.

which is readily seen in all cases when examined in the proper oblique view (Fig. 2).

It would seem that any ulcer crater located in the duodenum distal to the apex of the bulb should be classified as a post bulbar ulcer. Since it is not always possible to locate accurately the apex of the bulb when inflammation is present, the cases reported in this discussion are ulcer craters located in or distal to the genu superius

prone or supine position. When the patient is in this position, the genu superius is the most dependent portion of the duodenal loop. The effect of gravity can be utilized in filling out an irritable segment through which the opaque medium passes rapidly when the patient is in the erect posture. It is sometimes necessary to tilt the head of the table down a few inches below the horizontal plane to get the best position

for filling the proximal portion of the descending duodenum. The variability in the anatomical arrangement of the pars superior and the irritability in the presence

be useful in that pressure can be utilized to uncover a segment which might be partially hidden by a flaccid antrum or redundant pars superior.

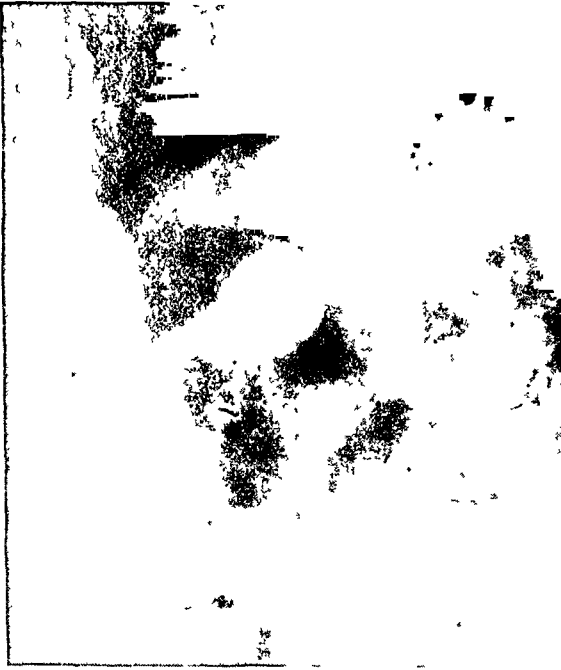


FIG. 3. Case 1 (267907). A seventy-two year old man was found to be anemic and to show gross blood in the stools. No other complaint. A smooth, rounded indentation of the lateral border of the descending duodenum with eccentric narrowing of the lumen is present. The ulcer crater is not distinctly seen. When the patient was placed on an ulcer diet the bleeding stopped. The final diagnosis was post bulbar ulcer of the duodenum.



of ulcer require a close scrutiny while rotating the patient. The positioning of the patient, preliminary to taking films with the Potter-Bucky diaphragm, has been well expressed by Schons²⁸ as follows: "The position must be so chosen as to yield the most satisfactory lengthening out of the upper duodenum." Spot films are found to

ROENTGENOGRAPHIC SIGNS

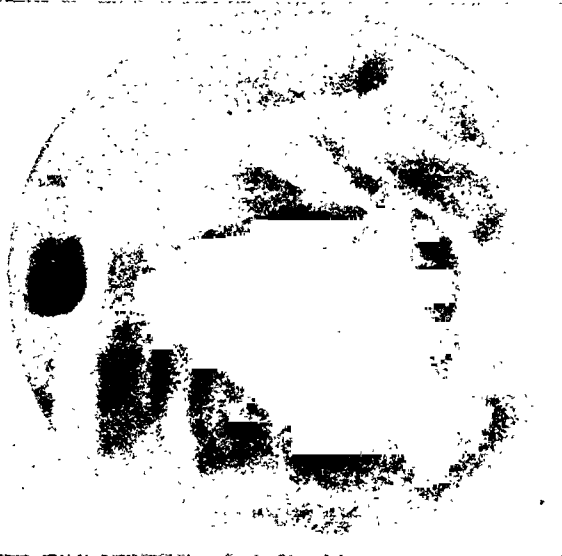
The most characteristic roentgenographic sign of post bulbar ulcer is an indentation of the wall of the duodenum at the level of the crater. The indentation is presumably due to spasm. It produces an eccentric narrowing. In some cases the indentation is smooth, rounded and nar-

rows the lumen to three-quarters of its normal width (Fig. 3 and 4). In others the area of spasm is more elongated. Occasionally more than one indentation is lo-

cave side of the genu superius. In some cases, however, it is found anteriorly or on the lateral side. Like the crater in the bulb, it will vary in size and depth. An



FIG. 4. Case II (247205). A physician, aged forty-one, had suffered with back pain for nine years. At times he had nausea, vomiting and abdominal pain. Hematemesis and melena were present at intervals. An ulcer crater is seen on the concave surface of the genu superius while there is a rounded, smooth indentation opposite the crater. An eccentric narrowing of the lumen is present. A subtotal gastrectomy was done.



cated opposite the crater. When the crater is located on the lateral side the localized indentation is seen on the mesial side. This sign has been present in all cases in which a diagnosis of post bulbar ulcer has been made.

The crater is usually seen on the mesial side of the descending duodenum or con-

associated ulcer in the bulb has been found in only one case.

Irritability of the proximal portion of the duodenum and of the bulb has been present in all cases. Enlargement of the mucosal folds and a loss of the usual regular markings of the valvula conniventes is a constant finding. Presumably this is due to

edema and inflammatory reaction in the wall. No definite stenosis which has produced dilatation either proximal or distal to the ulcer has been found in the cases examined (Fig. 6).

DIFFERENTIAL DIAGNOSIS

Lesions of the duodenum which might offer the greatest problem in the differential

paper on inflammation of the descending portion of the duodenum, and as stated by Sussman, show the presence of an ulcer crater. The high incidence of ulcer in the presence of duodenitis makes it obligatory to examine the patient in the positions which are sometimes necessary to show a post bulbar ulcer. When a patient is found to show unusual irritability, hypermotility

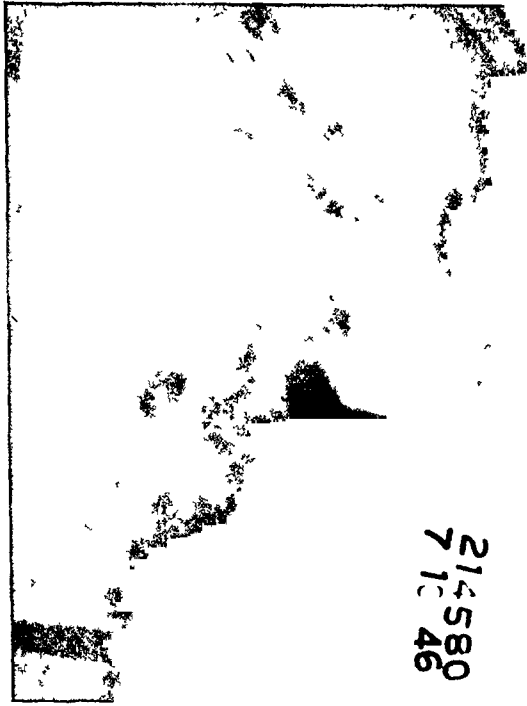


FIG 5 Case III (214580). A forty-four year old man had symptoms suggestive of a peptic ulcer for six years. He complained of pain in the abdomen but there was no hematemesis or melena. On an ulcer diet he was fairly comfortable. An ulcer crater is seen on the antero-lateral wall of the descending duodenum with a smooth, rounded indentation with eccentric narrowing at the level of the crater.

diagnosis of post bulbar ulcer are duodenitis, diverticula and neoplasms.

Duodenitis. Inflammation of the duodenum with and without ulcer formation has been discussed by Roeder,²⁶ Kirklin,^{14,15} Sussman,³⁰ and Wellbrock.³⁴ On the basis of his studies on 200 surgical specimens excised from the first portion of the duodenum Wellbrock concludes that there is histopathologic evidence of a definite relation between duodenitis and duodenal ulcer. In 8 cases of duodenitis reported by Roeder, 2 of these cases were found to have an ulcer when a second surgical exploration was done. In 32 selected, surgically verified cases reported by Kirklin,¹⁵ 20 cases showed the presence of an ulcer. Two of the 8 cases used by Sussman to illustrate his

and distorted mucosal folds of any segment of the proximal half of the duodenal loop (the roentgenographic signs of duodenitis), the presence of a smooth, rounded indentation of the wall and eccentric narrowing suggests the presence of a post bulbar ulcer. In the absence of the evidence of spasm, which has been found to be present in all cases with a large post bulbar ulcer crater, the possibility of a minute ulcer or mucosal erosion has not been excluded.

Diverticula. A barium-filled diverticulum might have the appearance of a barium-filled crater. Usually, however, the mucosal folds can be seen passing into or through the base (neck) of the diverticulum as contrasted with a clear zone or irregular folds about the margin of an ulcer crater. Al-

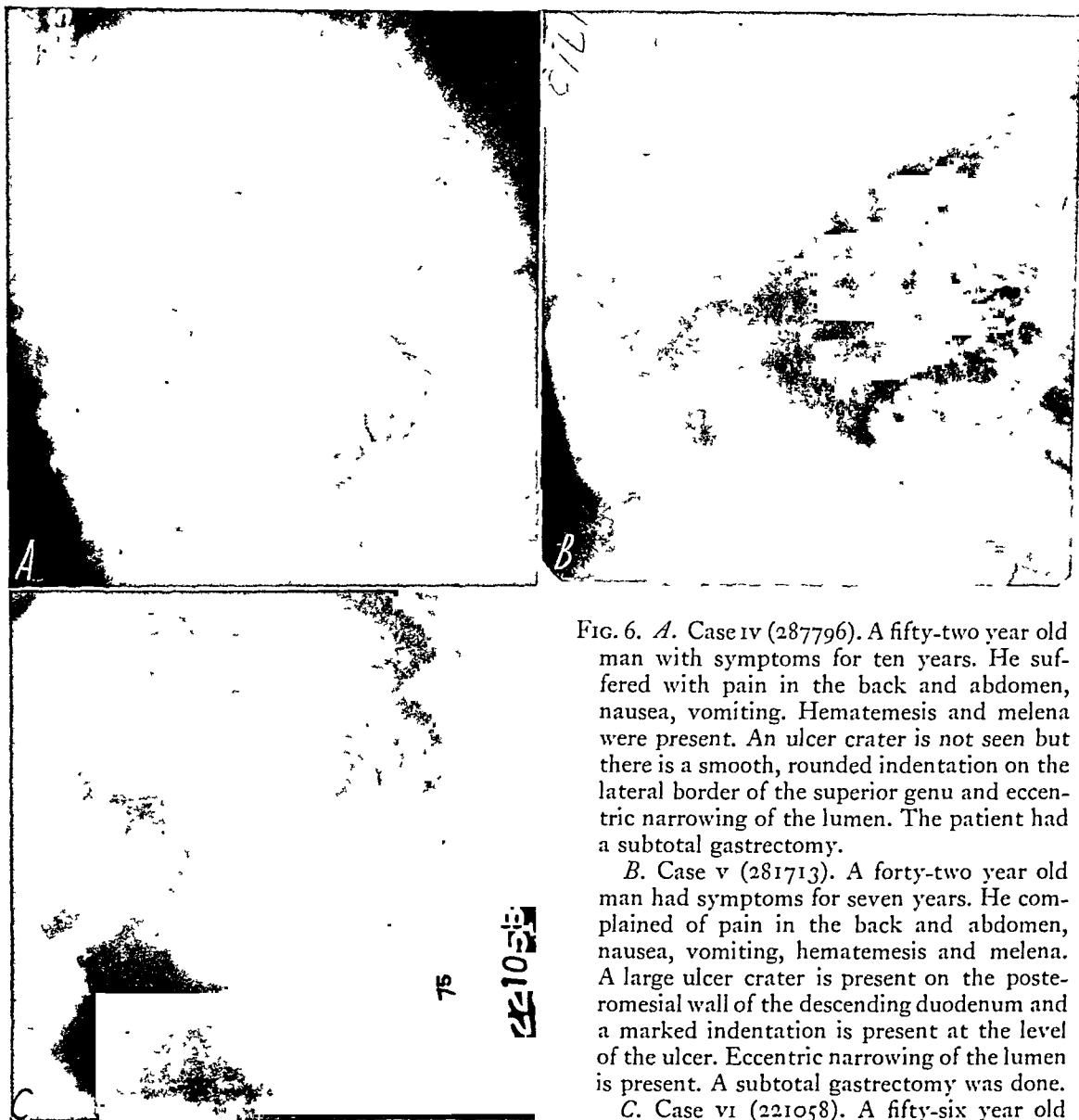


FIG. 6. A. Case IV (287796). A fifty-two year old man with symptoms for ten years. He suffered with pain in the back and abdomen, nausea, vomiting. Hematemesis and melena were present. An ulcer crater is not seen but there is a smooth, rounded indentation on the lateral border of the superior genu and eccentric narrowing of the lumen. The patient had a subtotal gastrectomy.

B. Case V (281713). A forty-two year old man had symptoms for seven years. He complained of pain in the back and abdomen, nausea, vomiting, hematemesis and melena. A large ulcer crater is present on the postero-mesial wall of the descending duodenum and a marked indentation is present at the level of the ulcer. Eccentric narrowing of the lumen is present. A subtotal gastrectomy was done.

C. Case VI (221058). A fifty-six year old man had symptoms for twenty years. His

chief complaint was pain in the back and abdomen. No occult blood was found in the stools and the patient gave no history of hematemesis. A large crater is seen on the mesial margin of the descending duodenum. Spasm is present at the level of the ulcer and the indentation commonly seen is quite pronounced. A subtotal gastrectomy was done.

though a diverticulum can occur in any portion of the duodenum, statistical studies³³ show that two-thirds of the cases are found projecting from the mesial border of the descending duodenum. In the absence of spasm or other evidence of inflammation in the presence of a smooth, rounded barium projection through the wall of the duodenum, the diagnosis of a diverticulum can be made with reasonable assurance.

Neoplasms. A malignant primary tumor growth of the duodenum shows a loss of the mucosa at the site of the lesion. The benign tumors, adenomata, are sharply delimited, rounded and usually are displaceable on pressure. The adjacent segment will have a normal appearance. Invasive tumors from the head of the pancreas will often show, in addition to the loss of mucosa, an enlargement of the duodenal loop because

of the presence of the tumor mass.

The less commonly encountered lesions, such as a fistula between the duodenum and gallbladder or duodenum and colon, will not offer any great difficulty in differential diagnosis if the fistulous tract is open. The distribution of the radiopaque media is pathognomonic in such lesions.

SUMMARY

Ulcer of the duodenum located distal to the bulb shows a smooth, rounded indentation of the wall at the level of the crater with an eccentric narrowing in all cases examined. Evidence of mechanical obstruction has not been found in the present series of cases. Enlarged, distorted mucosal folds, irritability of the bulb and hypermotility are associated findings. The ulcer crater is not always seen.

The use of exaggerated oblique projections with the patient in horizontal position or with the head lowered below the horizontal plane has been found to be helpful in disclosing the presence of post bulbar ulcer lesions.

The actual incidence of post bulbar ulcer is difficult to evaluate. In cases with hemorrhage from the gastrointestinal tract, particularly in those cases associated with back pain and symptoms of peptic ulcer, the possibility of post bulbar ulcer should be seriously considered.*

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REFERENCES

1. BAETJER, F. H., and FRIEDENWALD, J. Certain clinical aspects of peptic ulcer with special reference to roentgen ray diagnosis as observed in a study of 743 cases. *Johns Hopkins Hosp. Bull.*, 1918, 29, 177-183.
2. BALFOUR, D. C. Diseases of the duodenum. *Northwestern Univ. Bull.*, 1933, 33, 1-15.
3. BORMAN, C. N. Ulcer in the descending duodenum. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1943, 50, 752-764.
4. BRULE, M., HILLEMANN, P., GILBRIN, E., and CALLANDRY, L. L'ulcère de la deuxième portion du duodenum. *Arch. de mal. de l'app. digestif*, 1939, 29, 846-855.
5. BURCH, H. A. Incidence and significance of roentgenologic niche in duodenal ulcer. *Proc. Staff Meet., Mayo Clin.*, 1935, 10, 471-473.
6. CARMAN, R. D. Roentgen ray diagnosis and localization of the peptic ulcer. *California State J. Med.*, 1920, 18, 378-382.
7. CASE, J. T. Roentgen observations on the duodenum with special reference to lesions beyond the first portion. *AM. J. ROENTGENOL.*, 1916, 3, 314-326.
8. CIFARELLI, F. P. La úlcera extrabulbar del duodeno. *Rev. méd. de Rosario*, 1944, 34, 889-895.
9. COLE, L. G., and COLE COLLABORATORS. Radiologic Exploration of the Mucosa of the Gastro-Intestinal Tract. Bruce Publishing Co., St. Paul & Minneapolis, 1934, p. 59.
10. DEMIRLEAU, J. Les ulcères de la deuxième portion du duodénum. *Arch. de mal. de l'app. digestif*, 1939, 29, 856-864.
11. GRAHAM, R. R. The surgeon's problem in duodenal ulcer. *Am. J. Surg.*, 1938, 40, 102-117.
12. GUTMANN, R. A., and NGUYEN-DINH-HOANG. L'ulcère post-bulbaire. *Bull. et mém. Soc. de radiol. méd. de France*, 1937, 25, 341-346.
13. JUDD, E. S. Pathologic conditions of the duodenum. *Journal-Lancet*, 1921, 41, 215-220.
14. KIRKLIN, B. R. A roentgenologic consideration of duodenitis. *Radiology*, 1929, 12, 377-381.
15. KIRKLIN, B. R. Duodenitis and its roentgenologic characteristics. *Proc. Staff Meet., Mayo Clin.*, 1933, 8, 629-631. Also, *AM. J. ROENTGENOL. & RAD. THERAPY*, 1934, 31, 581-587.
16. MAYO, W. J. Pathologic data obtained from ulcers excised from the anterior wall of the duodenum. *Ann. Surg.*, 1913, 57, 691-694.
17. MILLER, T. G., PENDERGRASS, E. P., and ANDREWS, K. S. Statistical study of clinical and laboratory findings in gastric and duodenal ulcer, with special reference to roentgenologic data; based on records of 279 operatively demonstrated cases. *Am. J. M. Sc.*, 1929, 177, 15-33.
18. MOYNIHAN, B. G. A. Duodenal Ulcer. W. B. Saunders Co., Philadelphia, 1910.
19. MOYNIHAN, B. G. A. Problems of gastric and duodenal ulcer. *Brit. M. J.*, 1923, 1, 221-226.
20. MUCCI, L., and MARTINET, R. L'ulcère de l'estremo distale della I porzione del duodeno e l'ulcère duodenale extrabulbare. *Radiol. med.*, 1939, 26, 289-305.
21. PERCY, N. M., and BEILIN, D. S. Analysis of one thousand consecutive examinations of the stomach and duodenum from the clinical, roentgenologic, and surgical viewpoints. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1934, 32, 179-188.
22. PERRY, E. C., and SHAW, L. E. On diseases of the duodenum. *Guy's Hosp. Rep.*, 1893, 50, 171-308.
23. PORTIS, S. A., and JAFFE, R. H. Study of peptic

* For discussion see page 103.

- ulcer based on necropsy records. *J.A.M.A.*, 1938, 110, 6-13.
24. ROBERTSON and HARGIS. Quoted from Balfour.²
25. ROBINSON, W. W. Extra-bulbar or duodenal ulcer. *South M. J.*, 1934, 27, 759-763. Abstr. in *AM. J. ROENTGENOL. & RAD. THERAPY*, 1935, 33, 426.
26. ROEDER, C. A. Duodenitis. *Nebraska M. J.*, 1924, 9, 252-256.
27. ROSSONI, R. Contributo casistico allo studio dell'ulcera extrabulbare del duodeno. *Radiol. med.*, 1935, 22, 225-237. Abstr. in *AM. J. ROENTGENOL. & RAD. THERAPY*, 1936, 35, 838.
28. SCHONS, E. The right oblique horizontal (supine) position in the demonstration of duodenal ulcer crater. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1937, 38, 42-47.
29. STURTEVANT, M., and SHAPIRO, L. L. Gastric and duodenal ulcer. *Arch. Int. Med.*, 1926, 38, 41-56.
30. SUSSMAN, M. L. Inflammation of the descending portion of the duodenum. *Radiology*, 1935, 24, 691-700.
31. SUTHERLAND, C. G. Duodenal ulcer; comparison of roentgenologic and histologic findings. *Radiology*, 1927, 8, 111-116.
32. VIVIANI, R. Contributo alla conoscenza dell'ulcera extrabulbare del duodeno. *Radiol. med.*, 1930, 17, 698-734. Abstr. in *AM. J. ROENTGENOL. & RAD. THERAPY*, 1931, 25, 827.
33. WEINTRAUB, S., and TUGGLE, A. Duodenal diverticula. *Radiology*, 1941, 36, 297-301.
34. WELLBROCK, W. L. A. Duodenitis and duodenal ulcer. *Ann. Surg.*, 1930, 91, 533-539.
35. WOLKE, K. Ueber ulzero in der pars descendens duodeni. *Acta radiol.*, 1936, 17, 371-387.
36. ZANETTI, S. Ulcera o diverticolo ulcerato della III porzione del duodeno. *Arch. di radiol.*, 1933, 9, 1091-1102. Abstr. in *AM. J. ROENTGENOL. & RAD. THERAPY*, 1935, 34, 272.



PSYCHOSOMATIC RELATIONSHIPS IN PEPTIC ULCER*

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UNDOUBTEDLY the observant physician from earliest time has recognized the ease with which our bodily functions can be altered by emotional reactions. In recent years increasing emphasis has been placed on this aspect of medicine, and as a result a great variety of research data has been accumulated verifying these everyday observations of clinical medicine.

Possibly no organic system of the body is more sensitive to emotional disturbances than the gastrointestinal tract. Anatomically, the abundant afferent and efferent nerve supply is unquestionably of extreme importance in determining such localization. But of even more fundamental importance is the central role which the process of ingesting and eliminating food plays in the individual's life. Almost from birth the individual either consciously or unconsciously uses his digestive tract to express to some degree his feelings. The infant uses his entire body to express his emotions and the digestive tract is one of the main means through which the infant is able to express his reactions. As the child grows, differentiation of function occurs and the child learns to express his feelings through activity and speech rather than in bodily functions. Normally even in the mature person, however, the individual's emotional life is reflected in the gastrointestinal tract.

Such transitory alterations in function are a common experience to all of us. The sensation of "butterflies" in the stomach which a person notes when faced with a difficult situation or the proverbial diarrhea which follows a severe fright are two typical examples. In most individuals such evidence of dysfunction disappears as soon as the emotional stress is relieved. Under certain circumstances such states of altered function persist. Apparently, most individ-

uals who develop pronounced autonomic imbalance never have achieved emotional maturity. There is a tendency, moreover, for them to regress to a more infantile method of expressing emotion by projecting their feelings into bodily functions. Such organic language or somatization of feeling is the method by which the immature personality attempts to deal with an emotional problem which is beyond its scope to handle on a conscious level. In periods of relative calm these individuals may be asymptomatic or almost so, but under increasing stress they use this organ language to express their tension and anxiety with the consequent development of somatic symptoms. Under such conditions neither function is adequately served since digestion is interfered with and emotion is poorly expressed.

A wide variety of functional and organic gastrointestinal syndromes may result from these somatization reactions. They include various types of "nervous indigestion" due to motor and secretory disturbances in the stomach, mucous colitis, obesity, anorexia nervosa, and peptic ulcer, to mention a few of the commoner types. As is true in so many syndromes, the etiology of these conditions is quite varied. Certainly the multiplicity of opinions as to the origin of peptic ulcer clearly indicates that there is no one etiologic factor. Actually, the probabilities are that even in any one individual more than one factor is at work. Nearly all writers on the subject, however, have agreed that "nervous" factors are important, although no general agreement has been reached as to the degree of importance or the mechanism by which they act.

Many observations from clinical and experimental studies have illustrated the relationship of neuropsychiatric factors to

* From the Donner Service for Functional Disease, Gastrointestinal Section of the Medical Clinic, Hospital of the University of Pennsylvania. Presented before the Forty-seventh Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 17-20, 1946.

peptic ulcer. Brain surgery has shown that there are diencephalic centers which if stimulated produce gastric ulcer. The recent studies of Wolf and Wolff¹ have demonstrated that emotional factors such as anxiety, anger, and fear produce physiologic changes which may eventuate in acute ulceration of the gastric mucosa. The medical history and personality description of ulcer patients adds further confirmation. Very commonly recurrences of the ulcer have been precipitated by emotional stress. Outwardly such individuals vary from the energetic, ambitious, aggressive types to the passive submissive one. The former group appears to predominate numerically and is more frequently described in the literature. They are the executives who constantly drive themselves, allowing no time for relaxation.

The external personality differences would suggest that the psychodynamics in these two groups would be quite dissimilar. However, when the unconscious motivation is elicited in both groups the patterns are found to be quite similar; only the superficial phenomena are not alike. Insecurity and a tremendous need for affection are the basic driving forces in both. They constantly want to be loved and protected but because their demands are excessive, they generally never find the security which they are unconsciously seeking. The one type compensates for this by a veneer of aggressiveness. Unfortunately, this only accentuates his need since in the highly competitive society of today such striving usually evokes a similar attitude on the part of others, merely creating more insecurity for him. The passive individual, on the other hand, withdraws and shuns competition, at times even seeking most of his satisfaction in day dreaming. This withdrawal diminishes his external needs but leaves unsatisfied his inner emotional requirements, unless there is a complete psychotic break. The resulting anxiety and tension for both groups

surpasses the limits which can be tolerated by the personality. At this stage it is projected into bodily functioning. Such a displacement of the anxiety is socially acceptable. If the physiologic dysfunction persists an ulcer may result under certain circumstances, although the exact nature of the latter is not known.

The immediate management of the ulcer requires that the patient should be under the care of the internist or surgeon, depending on his clinical condition. Psychiatric therapy, however, is needed in instances to avoid recurrence of the ulcer. Naturally, psychiatry is no panacea and no claim is being made that it is the answer to the ulcer problem. If a personality evaluation discloses unconscious emotional factors which are disruptive in the individual's life, an attempt to create personality growth through psychotherapy should be attempted. In instances in which this has been successful the ulcer has not recurred since the emotional needs are less demanding.

Two cases of peptic ulcer which have been studied on our Functional Service are presented here since they illustrate certain of the points outlined above. The first patient during psychotherapy showed marked personality growth together with a disappearance of his ulcer symptoms. Psychotherapy was unsuccessful in the second case with recurrence of the ulcer.

CASE 1. An energetic, ambitious white male, aged thirty-five, who had had ulcer symptoms irregularly for twelve years, was finally hospitalized after a three months' exacerbation of his symptoms. He was referred to our Functional Service because of additional complaints: fatigue, irritability, muscular aches, insomnia, and mild paranoid trends. In recent months it had become evident that his varied symptoms had diminished his efficiency and stood in the way of further advancement. The patient was the younger of two sons. The father had died when the patient was three years old. Their mother was very enterprising and had managed to earn a good living, at the same time raising the children. She had always taken greater pride in the other son because he was so suc-

¹ Wolf, S., and Wolff, H. G. *Human Gastric Function*. Oxford University Press, New York, N. Y., p. 195.

cessful intellectually, socially and athletically. The patient never felt that he received as much of his mother's love. In an effort to compete with his older brother and thus to gain a larger share of his mother's affection, he worked after school, contributing very substantially to the family income. He also became a golf champion at eighteen. This got him in with a very sporty crowd, led to considerable drinking and a hurried marriage.

His mother disowned him at that point. This rejection created so much insecurity for him that he almost committed suicide. He was divorced shortly afterwards. He then began a never ending struggle for economic success in an effort to win back his mother's respect. He felt handicapped in his struggles by a lack of higher education; nonetheless, he succeeded very well. He married a highly intelligent woman with whom he felt considerable intellectual competition. After a few years the marriage was interrupted for some time by extra-marital interests. They had been reunited for about two years at this time but the husband was still very insecure in his relationship and had projected this onto his wife as paranoid ideas of infidelity. Intellectually he knew this was not true but emotionally it was very disturbing.

He was seen almost daily for a period of three weeks while his ulcer was being treated medically. He was then followed in twice weekly interviews for one month. As the story unfolded and the patient gained emotional insight into the unconscious conflicts which had been shaping his conduct there was a very marked change in his behavior and symptoms. Whereas in the beginning he had been very tense and restless, he became relaxed, his insomnia disappeared, together with the fatigue and muscular pains. At times as a result of the new insights the anxiety was temporarily intensified. The final step was the day he spontaneously said, "I am trying to use my wife as my mother. I want a safe rock to swim to." Gradually as he worked through this aspect of his insecurity the paranoid feelings disappeared.

Although the period of follow-up has not been long the patient reported that he has been asymptomatic. Occasionally, he has had tension due to environmental stresses but this has never become excessive.

CASE II. The patient was an extremely intelligent and capable Jewish engineer, aged forty-eight, who had had ulcer symptoms inter-

mittently for twenty-two years. He was admitted to the hospital when a six months' exacerbation of his ulcer symptoms grew steadily worse despite careful medical supervision. Throughout the war he had been under particular stress. He felt an added responsibility to assist the war effort to the utmost because he had many relations in Hungary. Psychiatric referral was made because of the additional symptoms: insomnia, anxiety dreams, irritability, fatigue and marked tension.

He was born in a small Hungarian village, the youngest of eight children. His father had been a very successful farmer who could afford to give all of his children a college education. The patient thought that he had been pampered to a mild degree, being the youngest, but otherwise his childhood had been uneventful. He had graduated from high school at the head of his class and had been quite active in sports. Even then he had a strong sense of orderliness, punctuality and inclination to be stubborn.

World War I began just as he graduated from school and he was called into the Army as a private. After a short period of active combat he went through the officer's training course. He was reassigned to the Infantry and was doing very well until he arrested a superior officer who while drunk had struck a private and who had refused to go to his quarters. As he said, "This is typical of my rigid belief that I should always stick up for the right." He was offered the choice of resigning from his regiment or facing a court martial. He chose the former and was transferred into a unit which corresponded to our Rangers. For the next three years he was almost continually in combat. It was during this period that he developed sufficient tension to leave him with constantly recurring anxiety dreams which have continued until the present time.

When he was discharged from the Army he finished his education, obtaining a degree in engineering. While in college he was faced with considerable racial discrimination which caused him to emigrate to this country in 1923.

His first years in the United States were marked by a financial struggle but he very steadily forged ahead. He married two years later and he has two teen-aged boys. He has worked very largely for one company. While he has at times been disappointed in not attaining the recognition which he thinks he deserves, he has never sought another job because he has felt that there was considerable racial discrim-

ination in his particular field. This he believed closed many otherwise promising doors. But of more importance apparently in creating emotional disturbance was the ever present conflict in his home. His wife is extremely unstable emotionally. She lacks entirely his sense of orderliness and thrift which is a constant source of irritation to the patient. Because she believed him to be unfaithful she has allowed him no personal freedom. To the patient every aspect of his life was full of frustrations and irritations. While it was his belief that the only solution as far as his marriage was concerned was divorce, his feeling of responsibility for his wife and sons was too strong to permit him to seek this way out of his problems.

As he related his story there was considerable release of tension although much of the insight was on an intellectual level with little emotional integration. His ulcer symptoms gradually disappeared and his varied manifestations of tension abated to a considerable degree. His ulcer appeared to be healed on roentgen follow-up but it was felt that the result was largely due to amigen therapy and the controlled hospital environment rather than to any lasting personality change. He was sent home on trial but was unable to meet the emotional demands of his environment and the ulcer recurred in a few weeks. He was then readmitted to the hospital and although he began to improve again, surgery was considered to be the only solution. He was subjected to vagotomy with complete eradication of his ulcer symptoms.

These two cases have been reported because they illustrate certain concepts which are important in the psychiatric evaluation of ulcer patients. Both patients had insecurity as a very dominant emotional problem; in the first patient the insecurity had its core from childhood. In the second case it appeared to develop much later in life, but here there was the additional factor of rigidity of the personality structure. As far as the environmental stresses could be evaluated, they were of much greater import in the second case. During psychotherapy the first patient showed more capacity for emotional growth. It was not unexpected when the second patient had a return of his ulcer symptoms once he was discharged from the hospital.

In conclusion, the importance of cooperation in the management of these patients should be stressed. The immediate treatment of the ulcer demands a careful evaluation on the part of internist and roentgenologist to determine the immediate course of therapy. Later, psychiatric evaluation and, where indicated, psychotherapy may be of extreme importance in producing a more lasting cure.

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DISCUSSION OF SYMPOSIUM ON
DUODENAL ULCER: PAPERS OF DRS.
TEMPLETON; BALL, SEGAL AND
GOLDEN; AND GASKILL

DR. JOSEPH C. BELL, Louisville, Kentucky. The psychosomatic influence on the etiology of duodenal ulcer and its bearing on response to therapy has been emphasized by Dr. Gaskill. The exact etiology of duodenal ulcer and the mechanism of the psychosomatic influence is not known but that it is of prime etiologic importance is apparent to any examiner who even briefly familiarizes himself with the histories of patients suffering from duodenal ulcer.

Dr. Golden and his associates direct our attention to a very special group of duodenal ulcers, those in the post bulbar region. That from 5 to 20 per cent of their patients having duodenal ulcers have had the ulcers in the post bulbar area seems quite high, but this may be due to the fact that some examiners have considered some ulcers within the bulbar area which actually were immediately post bulbar in their location. It has been our experience that ulcers in the post bulbar area are more prone to bleed severely than many of those in the duodenal cap and frequently they are less amenable to medical management.

I saw one patient with an acute perforated ulcer of the second portion of the duodenum in which there had been no previous history of discomfort. The perforation was closed and sutured. Repeated examinations over a period of several years showed no evidence of any deformity in the area of the previous perforation. The patient has been entirely free from symptoms since her operation.

Dr. Templeton emphasizes the importance of the presence or absence of an ulcer crater in determining the stage of healing. There is some

question in my mind whether the demonstration of a shallow crater always indicates activity but such is certainly the case in the vast majority of individuals. At times I have failed to demonstrate a crater very shortly after adequate medical therapy had been instituted even though it seemed obvious, from the clinical point of view, that healing was not complete.

The problem of the roentgen indications of the stage of healing becomes of paramount importance since vagotomy has assumed an important role in the treatment of peptic ulcer. The relief from pain and other gastrointestinal symptoms following this operation is dramatic to say the least. The roentgen findings in such cases constitute the only reliable basis for determining the stage of healing.

DR. B. R. KIRKLIN, Rochester, Minnesota. I think this has been a splendid symposium. I have no disagreement with Dr. Templeton on the importance of the crater as an indication of activity of a duodenal ulcer. From my experience, however, I still have considerable confidence also in irritability of the duodenal bulb as a sign of activity. I was a little disappointed to hear Dr. Templeton minimize the importance of clinical data as evidence of activity, although I agree with him that symptoms suggestive of duodenal ulcer do not necessarily mean that duodenal ulcer is present, for in a very high percentage of instances there is none.

However, from my examinations of physicians, I think I am safe in assuming that there are at least twenty-five in this room who have duodenal ulcer and I feel sure that most of those who have an ulcer have a great deal of confidence in their clinical symptoms as an index of the activity of their ulcers. For that reason I don't like to belittle the importance of clinical data in this connection.

A duodenal ulcer with a large shallow crater, such as acute ulcers often have, can easily be overlooked. I remember hearing Dr. Will Mayo remark on several occasions that he never could understand how the x-ray examiner could so often miss the big ulcers and very seldom miss the small ones. I think the reason is that when the crater is large and shallow there is not much deformity of the duodenal bulb and we neglect to compress the duodenal bulb and thereby demonstrate the crater.

With the very splendid paper of Ball, Segal and Golden, I want to agree whole-heartedly,

and I think it is a very timely contribution. Surely we have all had the embarrassment of missing post bulbar ulcers. One reason, perhaps, is the fact that we are so used to considering duodenal ulcers as occurring chiefly in the duodenal bulb, as they do, that after examining the duodenal bulb we fail to examine the second portion of the duodenum thoroughly. The craters of these ulcers, as Dr. Golden has shown, are apt to be quite large, and usually on the posterior wall. When the radiologist has made a diagnosis of ulcer in the second portion of the duodenum I suggest that he accompany the patient to the operation and insist that the surgeon search carefully, for the ulcer is in a difficult place to see and can easily be overlooked.

DR. C. N. BORMAN, Minneapolis, Minnesota. I have colored slides of two gross specimens that we have had in a series of these ulcers of the second portion that are unusually interesting, and I would like to present them to the Society at this time.

(Slide) This is a full-faced view of the first case showing the large ulcer crater. The second ulcer was present just below that area. This is a probe which has been placed in the orifice of the common duct to show the relationship of the ulcer to the common bile duct.

(Slide) The interest, in part, of this case is shown in this slide which is a sagittal section of the region of the ulcer. This represents the rather large crater. This is the mucous membrane of the part involved. This is the pancreaticoduodenal artery coming in from this side. This is a thrombus in the lumen of the artery and at this point the artery is completely eroded by the ulcer. This patient died of a massive hemorrhage, the source of which was unsuspected clinically. Our pathologist, Dr. R. W. Koucky, very carefully dissected out this artery and found it to be the superior pancreaticoduodenal artery.

(Slide) The second case is of interest because of the location of the ulcer, rather far down the descending duodenum. The pancreas is shown in this position and it shows nicely the relationship and the closeness of many of these ulcers to the body of the pancreas.

In our experience we estimate that we have had probably less than 5 per cent of ulcers of the duodenum either in the distal portion of the bulb or in the descending portion of the duodenum. We have now in the neighborhood of 12

cases that are definitely in the descending duodenum.

DR. LEWIS GREGORY COLE, White Plains, New York. May I express my great appreciation of the color photographs just thrown upon the screen as absolute proof of the type of lesion which Dr. Golden exhibited in his roentgenograms. These colored photographs, showing pathological findings correlated with roentgen findings, serve well to illustrate the few words I have to say.

I would ask Dr. Golden in what percentage of his cases, if any, was there any pathological proof of *his* roentgenological diagnoses, such as was presented in the last paper and illustrated by kodachrome photographs and photomicrographs? Dr. Templeton and Dr. Golden, here today, have presented to us roentgenological findings which they exhibited with great assurance; not only of diagnosis of an ulcer in the descending arm of the duodenum, but the size, shape, location and extent of the crater and its surrounding area of induration. The assurance with which these essays spoke of the size, shape and location of these craters, and of how much they disappeared under treatment, based purely on roentgenological findings without gross or microscopic proof, even of the existence of the lesion, leaves me a little concerned as to whether their assurance of healing was justified.

In my roentgenological career I have participated in many controversial questions concerning gastric cancers and gastric ulcers—whether they were simple true ulcers, as described by Aschoff, or ulcerating areas in localized malignant lesions; whether simple ulcers do heal or whether they do not heal; and whether a simple benign ulcer ever becomes malignant—but in these controversies, I never would have dared come before an audience like this for a gastrointestinal or surgical meeting, and make anything like the statements that have been made by either of these essayists, without having “honest to God” evidence that these statements were true.

DR. ROSS GOLDEN, New York, New York. I would like to ask Dr. Templeton whether he would be good enough to define exactly what he means by “active ulcer” and also the term “inactive ulcer,” which I think he used, if I understood him correctly.

I would like also to ask him whether he has had any instances of shadows which looked like

a crater on the pressure film and which persisted for months or even years after the patient's symptoms have disappeared. I had occasion to follow one patient for approximately two years who had previously had a duodenal ulcer. The little barium shadow with radiating folds remained unchanged all that time. The patient was symptom-free and I interpreted the shadow as probable evidence of a dimple in the scar which was probably epithelialized.

DR. FRANK WINDHOLZ, San Francisco, California. My experiences with healed gastric and duodenal ulcers are similar to those just mentioned by Dr. Golden. Scars following peptic ulcers, though covered by regenerated epithelium, often produce an indentation of the mucous membrane. This may be deep enough to permit a collection of barium which in turn causes the appearance of persistence or recurrence of the niche. The indentation produced by the scar is due to incomplete filling of the crater by granulation tissue and to shrinkage of the granulations.

Disappearance of the niche does not necessarily mean that the ulcer has healed. The crater may have filled up with blood clots, preventing the barium from entering. This is not known widely enough because the pathologist, as a rule, removes the clots from the crater in order to establish the source of the bleeding. He considers the perforation of blood vessels rather than the presence of blood clots as the integral part of the disease. Our diagnostic problems are somewhat remote to him. Several years ago I observed the disappearance of the niche of a gastric ulcer and thought that it had healed. A few days later the patient died. At the autopsy the crater was filled with blood clots. A microscopic examination revealed that inflammatory changes were going on beneath the clots. A short time later I had the opportunity to make three additional observations of this kind.

I feel that significance may be attached to these two groups of findings in connection with the problems made evident from the excellent presentation of Dr. Templeton.

DR. TEMPLETON (closing). I have a number of questions. I don't think I have the time to answer them all.

The thoughts of the discussers have been most stimulating. Any discussion on duodenal ulcer is always controversial.

Dr. Bell stated, if I heard him correctly, that

he was not sure that a crater always indicated activity. I think it does. I look upon a crater as the ulcer itself, as the open sore. If a crater is seen, it must represent an ulcer by definition.

Dr. Bell spoke about pain in an ulcer. I have seen many patients with ulcer who were relieved of their pain by treatment, but in whom crater could still be demonstrated. Many of these patients were relieved of pain in from five to ten days after treatment was started. Crater was still present. Some of the craters, in due respect to Dr. Cole, were confirmed later at surgery.

There must be a group of gastric ulcers which do not cause pain. Pathologists who do careful examinations find a high percentage of ulcer scars in both the stomach and the duodenum, in the patients in whom the history does not indicate an ulcer. There are the so-called silent ulcers which often are first manifest by a massive hemorrhage.

I think the "symptomless" ulcer must be more frequent than we realize. The ulcer apparently occurs rapidly, lasts two or three days and then disappears rather promptly. Why? I can't answer the question.

Also, Dr. Bell made the statement that the roentgenoscope is of primary importance. With that I entirely agree, but I don't think that one can depend entirely upon the roentgenoscope. There may be something wrong with my eyes, but I cannot see all ulcers under a fluoroscope. I depend on the spot machine, particularly in the person who weighs about 250 or 300 pounds, who is about five feet six, and in whom the bulb can be seen in only the oblique view. In these patients one cannot always be sure the bulb is deformed or not. I agree with Dr. Golden who emphasized the diligence one must apply in order to find ulcers.

In the very heavy patients, one trick is very helpful. If the bulb fills, with the patient either in the prone or standing position, the mucosa coats with barium. The patient is now placed on his back and turned toward his left side. Air from the stomach runs into the bulb and in a large number of cases a double contrast view of the bulb appears. Sometimes a crater stands out on the films made with the patient in this position. It is difficult to realize how a crater which shows so well on films could not be seen at fluoroscopy.

Dr. Kirklin mentioned irritability. It is true that some bulbs containing ulcer are irritable, but if too much dependence is placed on irrit-

ability, I am afraid that ulcers will be diagnosed in persons who do not have them. I am sure that Dr. Kirklin didn't mean it that way. To me, irritability is a very indirect sign.

Dr. Golden asked about active and inactive ulcer. I used these terms loosely. Strictly speaking, if I am to be consistent, I cannot speak of an inactive ulcer. If a crater disappears and only the scar remains to produce the deformity, the patient does not have an ulcer in the strict sense of the term. In reports I speak of ulcer scar either with or without crater. Dr. Golden asked about instances of so-called spurious crater—flecks of barium which might look like crater. I am on record as reporting a few instances of crater in patients in which there was no evidence of ulcer. On one occasion, the figure reported was 0.3 per cent. I don't think I am always that accurate. I think, however, that if a person is careful at fluoroscopy and examines the patient more than once during treatment, the error is small if one is familiar with the criteria for identifying a crater.

Dr. Gaskill spoke of the psychosomatic and indicated that the gastrointestinal symptoms come over the nerve paths. I wonder if they do. The relationship could be studied in patients having vagotomies and sympathectomies. I have observed both types. The gastrointestinal tract is usually thrown out of balance for a week or ten days and then returns to its former condition. I wonder if the author has any evidence in which the psychosomatic relationship, as far as the gastrointestinal tracts are concerned, holds true when the nerve pathways are interrupted?

DR. GOLDEN (closing). I thank the discussers very much for their remarks. Dr. Borman's photographs of his pathologic specimens were very beautiful.

Dr. Cole as usual brought his needle with him. About thirty-five years ago, Dr. Cole had a big battle on his hands. That was when he was in process of establishing the significance of deformity of the duodenal bulb or, as he called it, "the cap" as evidence of duodenal ulcer. Since Dr. Cole did that, the x-ray examination and particularly the quality of the examiners has improved over the past thirty-five years and the accuracy of Dr. Cole's observation has been proved time and again. The detection of duodenal ulcer nowadays is so accurate that proof by either a surgeon or a pathologist is not required. Furthermore, the vast majority of

patients with duodenal ulcers do not have timely autopsies or even surgical operations, and the clinicians now refer to duodenal ulcers or gastric ulcers as "proved by x-ray." That is the result of the pioneer work that Dr. Cole did so many years ago. Following him, Åkerlund in Sweden and Berg in Germany and a number of other radiologists have made the diagnosis of duodenal ulcer highly accurate so that we do not have to do autopsies and operate on the patients to prove it.

However, in my haste to cover the topic in the allotted time, I forgot to mention that 4 of the patients shown were operated upon and the ulcers were observed by the surgeon. For this neglect, I apologize.

I should add that Dr. Ball did not have time

to make statistical studies of duodenal ulcers at the Presbyterian Hospital with regard to the frequency of location. Statistical medicine, after all, is useful only to a certain extent. One patient in a hundred may have a certain disease and to that patient the disease is just as important as if it occurred in one out of two individuals. We must not go too far in drawing conclusions from statistics and should not allow a condition encountered infrequently to escape detection merely because it is infrequent. After all, does it matter whether post bulbar ulcer occurs in 2 per cent, 5 per cent, or 20 per cent of ulcer cases? It is my impression that among our cases the figure is not anywhere near as much as 20 per cent and is probably less than 5 per cent.



THE ROLE OF THE ROENTGENOLOGIST IN THE DIAGNOSIS OF POLYPOID DISEASE OF THE COLON*

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THE importance of the diagnosis of polypoid lesions of the colon should always be emphasized. Not only do these lesions carry a threat of repeated hemorrhage but also the danger of producing obstruction by intussusception and the danger of malignancy.

Certainly the major part of the task of the roentgenologist is that of discovering the presence of the suspected lesion. Toward this end we will discuss the methods and techniques that can be used, both old and well known, and others that have not been stressed. A further intent is to attempt to indicate which of several methods should be chosen. Besides this, old and new criteria of diagnosis will be presented and some pitfalls in diagnosis will be pointed out.

But besides this accepted role, the roentgenologist must retain and realize his responsibility as clinician for the patient and as consultant to the internist or surgeon. How can he be of aid to the patient beyond the basically limited scope of roentgenologic proficiency? How can he aid the referring physician beyond demonstrating the presence of a colonic mass?

METHODS AND CRITERIA OF DIAGNOSIS

Obviously, a patient must be prepared in such fashion that the colon will contain as little fecal content as possible. The method of preparation should be individualized. In all instances supper on the evening before examination can be eliminated. It is probably best to permit the patient breakfast because this will act as a stimulus to defecation. Non-irritating enemas should be given the morning of ex-

amination. The use of catharsis, although it may result in a cleaner colon, is not always justified. It is contraindicated in instances of obstruction, actual or suspected; also it is contraindicated in severe bleeding or severe diarrhea, particularly since the source presumptively is not recognized. Some patients, moreover, cannot be induced to take cathartics; the social level of the patient may play a part. Furthermore, ideal preparation is rarely obtainable in out-patients either because of incomplete instruction by the referring physician or carelessness or inability on the part of the patient.

There are many excellent discussions of technique in the literature and the methods are, for the most part, well standardized. Initially only the single contrast enema and the post-evacuation film were employed. The double contrast visualization of the colon was subsequently introduced by Fischer^{2,3} in 1923 and later popularized and modified by Weber^{10,11} who employed stereoscopic studies. Also now in general use is the roentgenoscopically controlled compression technique,^{1,4,6,8} although this has never been stressed to the degree that has the double contrast study.

Polypoid lesions can be rather elusive. The first roentgenologic clue comes during the initial filling of the colon with the barium sulfate-water suspension. Roentgenoscopically, an evanescent concave border in the advancing opaque medium may be seen; or before the walls of the colon are completely separated by the liquid, a filling defect may appear surrounded by the contrast substance. In almost every case to be presented the barium would com-

* From the Department of Radiology, Jefferson Hospital, Philadelphia, Pennsylvania. Read before the New York Roentgen Society November 18, 1946.

pletely hide the pathology when the colon was expanded. Compression with a finger or with a non-opaque device at this point again revisualizes the defect of the main mass of the polypoid growth under the screen. Spot pressure films, reproducing what the palpating hand discloses, bring out the defect pictorially. Sometimes a questionable mass is crushed by compression and it no longer is a differential problem. However, if the tumor is on a pedicle, it may move from place to place and give the impression of fecal content. We have seen a lesion in which the main mass was in the sigmoid at one moment and in the distal descending colon at another. Here, again, compression and filming are used in an effort to demonstrate a pedicle and possibly its point of origin.

Since a lesion is usually first encountered in the sigmoid and time is consumed in manipulation at this site, the flow of barium should be stopped at the first suspicion. Subsequently two alternatives are available. One may have the patient evacuate; this procedure will further cleanse the bowel and aid in the differentiation between fecal shadows and filling defects which are definitely arising from the bowel wall. This is of most value in the patients improperly prepared. Usually, one may continue with the examination uninterrupted, particularly if the caution of stopping the ingress of the enema has been observed, for very little opaque medium will have gone beyond the point under consideration. In this fashion all compressible portions of the large bowel are studied until the entire colon is outlined. The pre-evacuation film is then obtained.

The patient must be re-examined roentgenoscopically after evacuation of the enema. If no further suspicious shadows were found in any portion of the colon during the filling, and if only a single lesion interrupts the mucosal pattern at the post-evacuation screening, the study is completed with the post-evacuation roentgenogram. However, the observer must be satisfied that unevacuated barium content will

not obscure the mucosal detail of this film and thereby hide small tumors. If he is dissatisfied the patient is returned to stool repeatedly until optimum contrast is obtained.

Whenever the roentgenoscopist is uncertain of the findings in non-palpable areas he then should employ double contrast studies followed with stereoscopic roentgenograms. Again, however, the same consideration as to proper mucosal relief applies.

Occasionally, we are fortunate enough to visualize dimpling or puckering of the bowel wall at the site of attachment of the polypoid growth. This particularly serves as a valuable sign when either a pedicle is too short to demonstrate or when no pedicle exists; it points out the definite site of attachment, and like the pedicle, conclusively proves the existence of pathology. Either is pathognomonic. We feel that this dimpling is probably due to the stretching effect of the pressure exerted and that it is actually the invaginated shadow of the very base of the stalk or the area of attachment of a sessile tumor which is exaggerated by the inward pull on the mucosa.

Most roentgenologists probably feel that the demonstration of lesions of the rectum, exclusive of congenital anomalies, strictures and fistulas, is not specifically their problem; nevertheless it is well to start the initial flow of opaque medium extremely slowly, the tube being partially occluded, so that at least the moderate-sized to large tumors be not completely overlooked during roentgenoscopy. The post-evacuation observations are particularly helpful in these cases. Oppenheimer⁷ controls the amount of barium suspension which is introduced into the rectum by injecting it through a urethral catheter by means of a syringe. He feels that many lesions in an incipient stage and without symptoms may escape the examining finger and proctoscopy is then omitted. Therefore by use of his suggested technical modification a number of early and small lesions may be dis-

covered in the rectum before being suspected clinically.

RESPONSIBILITY TO THE SURGEON OR INTERNIST

Previous to restudying our cases we felt that in patients with polypoid lesions it was essential to reproduce the findings during at least two examinations before surgical intervention could be advised. At the present time our opinion is that this need be done only when neither a pedicle nor bowel dimpling can be demonstrated.

The roentgenologist, having satisfied himself that single or multiple tumors are present, next must satisfy the referring physician. The lesion must be faithfully reproduced on good roentgenograms. Further, its extent must be definitely depicted because in determining the surgical approach this is of primary consideration. It logically follows that in the isolated pedunculated mass, a demonstration of the point of attachment will greatly aid the surgeon in opening the bowel at the exact site.

Another responsibility is to recognize that no method is always infallible in demonstrating all the lesions when several tumors may be present and that the surgeons become aware of the limitations of roentgen diagnosis. The surgeons then will continue to search during surgery by direct palpation.

RESPONSIBILITY TO THE PATIENT

The roentgenologist best aids the patient by having a thorough knowledge and concept of the entire disease entity. Specifically, there should be nothing in his report to the referring physician that in any way implies that the lesion is surely benign. No one now can deny that the benign polypoid mass must be considered a precancerous tumor. The choice of the term "polypoid lesion" should be specifically employed rather than the term "polyp" because the latter may give a false impression of benignancy.¹¹ The roentgenologist should be the first to agree that there is nothing in his diagnostic method that can differentiate a

benign polyp from a malignant polyp or predict which benign lesion will not become carcinoma. It is of no value to the individual patient that the pedunculated tumor is less frequently malignant than the non-pedunculated tumor. The size of a polyp is no accurate index of histopathology. Swinton and Warren⁹ showed that 76 per cent of their malignant adenomas were less than 1 cm. in diameter. They also pointed out that in 14 per cent of 827 patients with malignant tumors of the colon and rectum the lesions definitely could be demonstrated to have had origin from benign mucosal polyps.

Second, the roentgenologist must suggest at every opportunity that postoperatively these patients should be restudied at frequent intervals, regardless of the histopathology of the surgical specimen. We have noted in reviewing cases examined in our department that only those in whom the histopathology indicated malignancy have been returned for re-examination. This optimism for the others is not warranted.

Third, he should be cognizant of the fact that 30 per cent of the combined total of polypoid tumors of both rectum and colon are found beyond a sigmoidoscopic reach of 10 inches.⁹ He should not be influenced by his observation of external hemorrhoids during the introduction of the tip of the enema tube in patients with histories of bleeding. He should also be impressed with the frequency of the disease. In 7,000 autopsies Lawrence⁵ found 2.37 per cent of the cases to have had polyps in the gastrointestinal tract, the greatest majority in the colon and rectum.

Besides these specific concepts in regard to the patient, the roentgenologist should be generally aware of the features in the clinical background both as to complaints and other studies. A clinical grouping of a patient will be found to be invaluable in assisting him in his technical management, in arousing his consciousness to the diagnostic possibilities, and in placing him on guard.

Patients with polypoid disease seem to fall into four different clinical groups. In one group the patient gives a history of definite hemorrhage from the bowel, the sigmoidoscopic examination reveals no lesion which could have given rise to the bleeding, and the roentgenologist then is charged with the responsibility of examining the colon above the rectosigmoidal junction for the bleeding point.

The second group is composed of those patients in whom the history of bloody stools is associated with a proved growth in the rectum or rectosigmoidal area by palpation or proctosigmoidoscopy, and in whom the roentgenologist is charged with proving or disproving the existence of lesions higher in the colon.

The third group consists of those patients who are probably most representative clinically of our every-day type of roentgenologic problem. Within this class fall those patients whose complaints are either non-specific or minor, or may even include bleeding, but in whom sigmoidoscopic study has not been done. Most of these studies might be considered "elective" or "for exclusion."

In the fourth group are those patients whose complaints are clinically those of ulcerative colitis but who ultimately are found to have multiple polyposis (adenomatosis coli, familial polyposis of the colon). If sigmoidoscopic study has been done the roentgenologist is forewarned and the diagnostic technique employed will be that of the double contrast method universally recognized as the best for roentgen demonstration of these diffuse multiple lesions. It must be borne in mind that multiple polyposis may be simulated by ulcerative colitis not only in the clinical but also in the roentgenologic manifestations of two forms of the latter disease. In one type the mucosa between ulcers will appear to project into the bowel lumen, and if the ulcers are not undermined (collar-button pattern) or otherwise readily recognizable, the cobble-stone pattern of the pseudopolyps may be mistaken for true adeno-

mata. In a second form of ulcerative colitis (polyposis cystica intestini) a generalized polyposis may come into being. In fact, this stage of ulcerative colitis is included in general classifications of polypoid disease of the colon. The two disease processes may co-exist.

Group I: Hemorrhage; negative sigmoidoscopic examination.

CASE I. M. S. (HH 2661), a white male, aged forty-six, was hospitalized because of blood-streaked stools noticed over a period of one year. There had been urgency with scanty stools from three to six times daily. Seven months before admission he had had a rectal polyp removed. The family history is non-contributory. Sigmoidoscopy with visualization for 12 inches showed no pathologic changes.

A barium enema study demonstrated a mid-sigmoid polypoid lesion on a long pedicle. The mass was visualized on conventional films, and double contrast films. With pressure the pedicle was clearly defined (Fig. 1 and 2). No other masses were found in the colon.

The surgical specimen was 3 by 2 by 2 cm. in size. The pedicle was 1 cm. in diameter. The tumor consisted of a fibrous core covered by normal intestinal mucosa. Some of the glands were dilated and cystic. The diagnosis was benign polyp of the sigmoid.

CASE II. L. K. (H 3451), a white female, aged forty-seven, was admitted complaining of episodes of rectal bleeding, occurring at approximately weekly intervals for two years. There were no other gastrointestinal complaints. Her father had died of cancer of the rectum; other features of the family and past histories were irrelevant. Sigmoidoscopy did not reveal any pathology.

A barium enema, single contrast study, demonstrated, with compression over the sigmoid, a single pedunculated polypoid lesion associated with dimpling of the bowel wall (Fig. 3 and 4).

The polypoid mass removed at operation measured 2 cm. in diameter; its pedicle was 1 cm. long and was attached in the sigmoid. Microscopically, the tumor was covered by normal mucosa and the histopathologic diagnosis was benign polyp.

CASE III. A. S. (KK 938), a white male, aged sixty-two, was admitted to the hospital because



FIG. 1. Case 1. *A*, ordinary opaque enema. Polypoid lesion is concealed *B*, post-evacuation film showing pedicle of the tumor but the main mass is still lost in the shadow of the barium

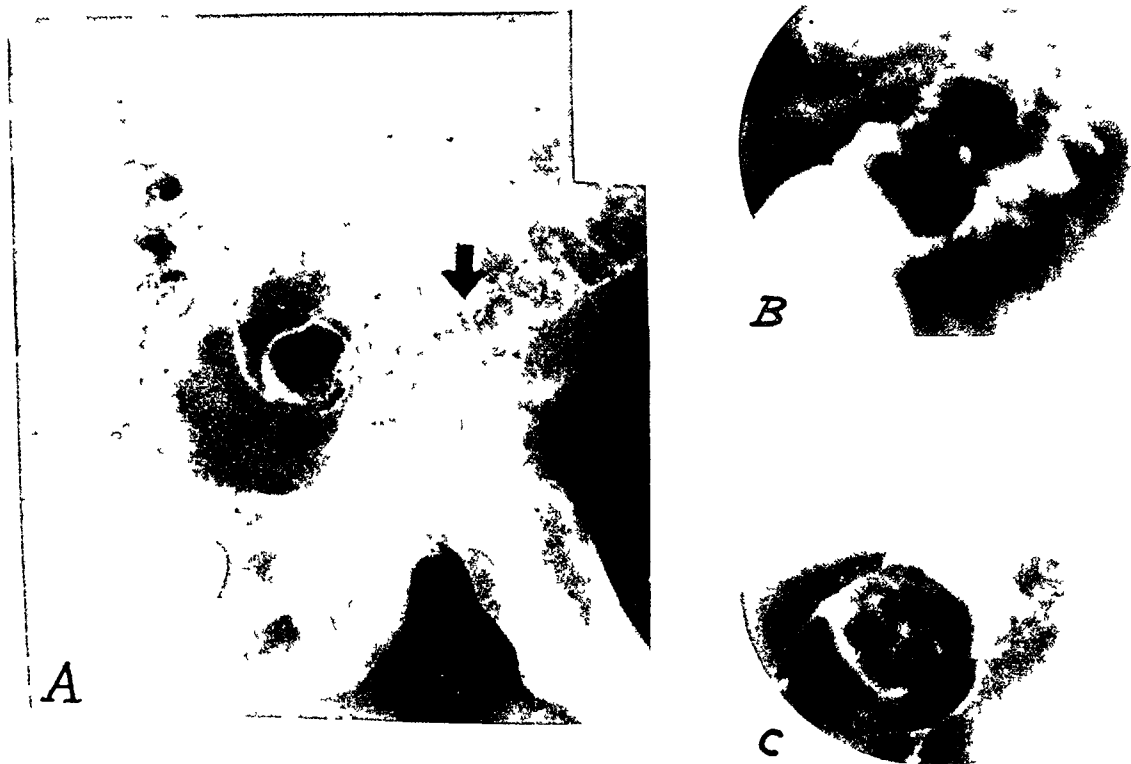


FIG. 2. Case 1. *A*, double contrast study showing the entire structure of the growth including its site of attachment (arrow). *B*, compression film, single contrast. The tumor and its pedicle appear as shadows of decreased density. *C*, compression film, double contrast. Both portions appear as shadows of increased density.



FIG. 3. Case II. *A*, barium enema—lesion barely perceptible. *B*, double contrast film showing polypoid mass.

of loss of a large quantity of blood by rectum associated with faintness and profuse sweating two days previously. Before this he had occasionally noticed blood in his stool, but attributed it to hemorrhoids. Hemorrhoidectomy had been performed ten years before. The family history was non-contributory. Sigmoidoscopic examination to a depth of 10 inches showed no evidence of ulceration or new growth. There were some small internal hemorrhoids, but they did not appear to be the source of the profuse bleeding.

Initial single contrast barium enema study showed a polypoid tumor in the mid-sigmoid. The patient was restudied after two days and both the tumor and its pedicle were visualized with compression (Fig. 5).

The excised specimen measured 2 cm. in diameter and was connected to a pedicle 1 cm. in length. Histopathologically many masses of cells were invading the tissue. They were secreting a large amount of mucus and were described as atrophic. The diagnosis was colloid carcinoma of the sigmoid.

A barium enema study three months following surgery showed no evidence of recurrence.

Comment. These 3 cases, surgically proved, illustrate how faithfully good compression technique can depict the outline of the complete gross specimen, both the tumor and its pedicle. The demonstration of the pedicle and its point of attachment is

of great importance to the surgeon for he then knows exactly where to open the bowel lumen to come directly down on the base of the pedicle. The dimpling of the bowel wall in Case II is noteworthy, but its importance in this instance, although significantly corroborative, is not as great as in a subsequent instance—Case VI.

Case III clearly illustrates the well

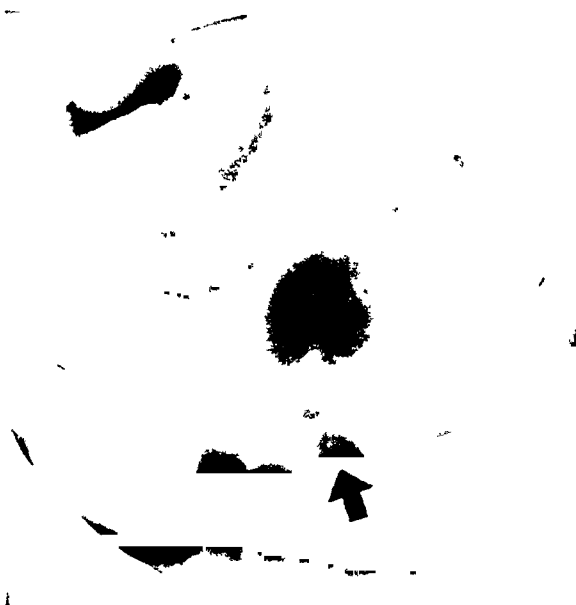


FIG. 4. Case II. Compression film over sigmoid showing the main mass and its pedicle with dimpling (arrow) at the base of the pedicle.



FIG. 5. Case III. *A*, polypoid lesion of the sigmoid shown with its pedicle on roentgenogram after barium enema. *B*, compression film.

known fact that the presence of a pedicle does not assure benignancy. This case emphasizes the reason for our preference for the term "polypoid lesion." Since at the first examination neither a pedicle nor dimpling was demonstrated, the patient was restudied to assure constancy of the findings before surgery was recommended.

Group II: Hemorrhage, with a proved

growth in the rectum or rectosigmoid clinically.

CASE IV. M. B. (K 6801), a white male, aged fifty-six, was admitted complaining of occasional blood-streaked stools for over a year. At intervals there was pain on defecation. Past and family histories were non-contributory. At sigmoidoscopy several polypi were seen scattered around the circumference of the bowel 8 inches above the anal orifice. A biopsy speci-

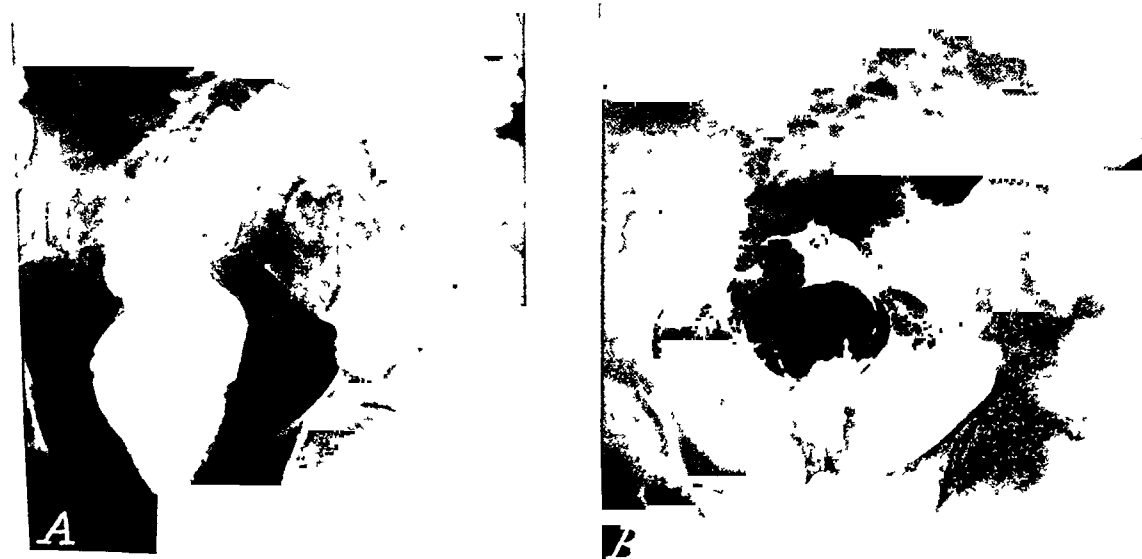


FIG. 6. Case IV. *A*, barium enema showing a rounded shadow of decreased density in the sigmoid. *B*, double contrast film demonstrating the tumor with its pedicle as an opaque mass.

men was described histopathologically as a benign polyp.

An initial barium enema study, single contrast, showed a fairly large round shadow of decreased density near the rectosigmoidal junction (Fig. 6A). A subsequent study, using a double contrast technique and stereoscopic films, demonstrated the polypoid mass with its short but broad pedicle as a shadow of increased density (Fig. 6B).

Surgical treatment had not been instituted at the time of preparation of this report.

CASE V. J. D. (K 81), a white male, aged fifty-six, was admitted because of acute urinary

Pathologically, it measured 5 cm. in diameter and 3 cm. in height; the base was small and limited to the intestinal mucosa. Histopathologically, it was considered a border line lesion, possibly malignant.

Comment. In Case IV the presence of a lesion above those seen sigmoidoscopically was established. Again, since the first examination did not demonstrate a pedicle and since the shadow may possibly have been a fecal mass, a second study was deemed necessary. Further, since neither the palpating hand nor a small compression

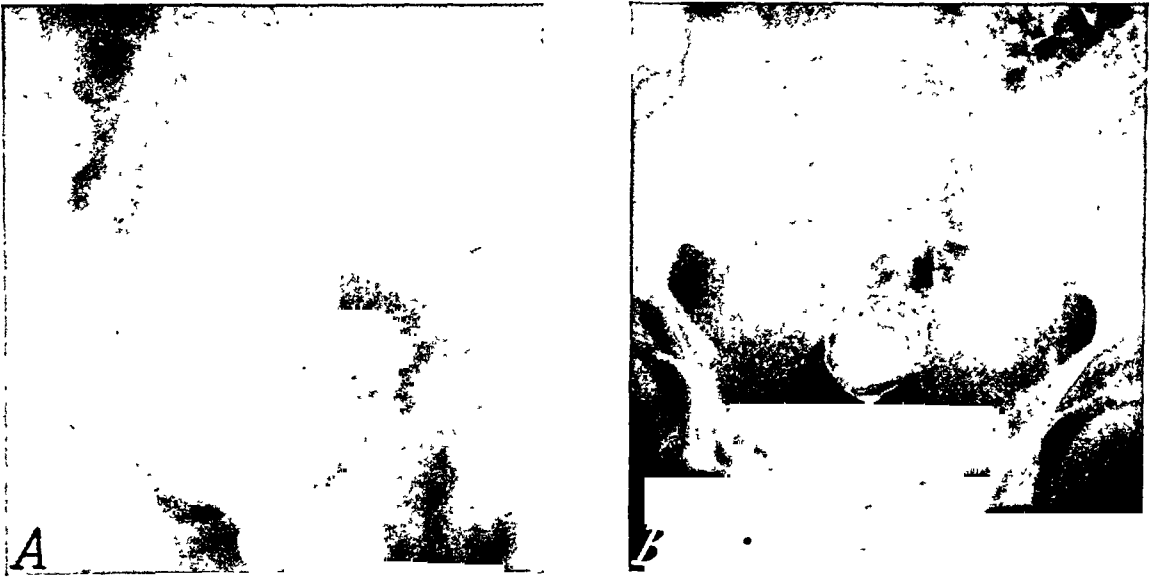


FIG. 7. Case v. A, barium enema hides rectal lesion. B, post-evacuation film shows polypoid lesion.

retention from prostatic enlargement. An intrarectal mass was palpable at the tip of the examining finger. Inquiry indicated that red-streaked stools had been observed intermittently for one year. No other gastrointestinal complaints were made. Family and past histories were non-contributory. Although the rectal growth was reported as benign at biopsy, the proctoscopist felt that the lesion appeared malignant and a Miles' resection was advised.

Barium enema examination was begun with a very slow injection of the opaque medium and the rectal mass was readily apparent. Complete filling of the rectum entirely concealed the tumor. A roentgenogram after partial evacuation indicated the polypoid mass as a shadow of increased density (Fig. 7).

device could reach the area, stereoscopic double contrast study was considered beneficial at the subsequent examination.

In Case v the examination of the rest of the colon ruled out the presence of higher lesions. The roentgenoscopist could appreciate the presence of the tumor only because of cautious and slow filling of the rectum. Multiple views with the rectum completely filled failed to visualize any abnormality. The lesion was best observed after the proper amount of evacuation had been obtained.

Group III: Hemorrhage or nonspecific complaints; no sigmoidoscopic studies.

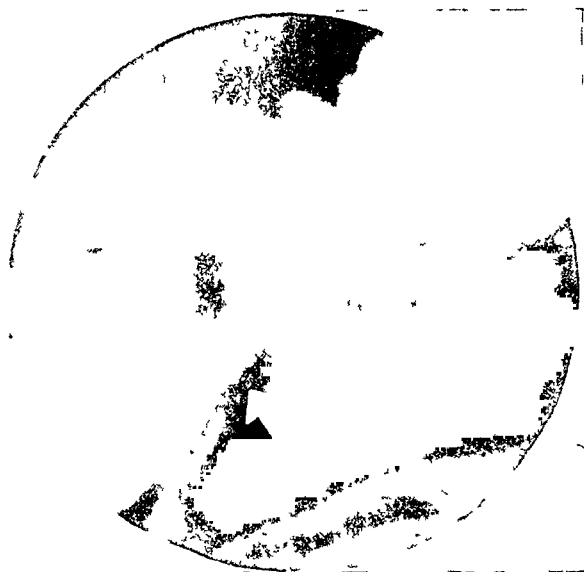


FIG. 8. Case VI. Small polypoid mass in sigmoid with dimpling (arrow) at its base.

CASE VI. R. W. (KK 227), a white male, aged sixty-four, was admitted because of weight loss of 20 pounds within six months. During this period there had been mild upper abdominal pain and slight nausea. Stools had been normal.

Roentgen study of the upper gastrointestinal tract revealed no pathology. The barium enema study, single contrast, showed the presence of a polypoid mass in the mid-sigmoid producing

puckering or dimpling of the intestinal wall (Fig. 8). A subsequent sigmoidoscopic examination showed the rectum and lower sigmoid to be normal.

The resected specimen consisted of a polypoid mass 0.5 by 1.5 cm. in diameter with a base 5 mm. in diameter attached to a piece of mucosa 1.0 by 1.0 cm. Histopathologically beneath the epithelial covering there were masses of glands infiltrating the wall. There were many hyperchromatic nuclei and mitoses. The diagnosis was adenocarcinoma of the sigmoid. A subsequent barium enema study, four months postoperatively showed no evidence of recurrence.

CASE VII. I. M. (KK 2989), a white female, aged forty-two, was admitted complaining of a slight amount of blood in the stools associated with mild diarrhea. The past and family histories were non-contributory.

Barium enema with compression showed a polypoid lesion with a pedicle in the sigmoid. This was demonstrated on two occasions. Dimpling of the bowel wall at the base of the stalk was apparent (Fig. 9).

The specimen removed was 2.5 cm. in length and 1.0 cm. in width. The length of the pedicle itself was 1.5 cm. Histopathology showed hyperplastic but regular columnar epithelium covering a central core of fibrous tissue. The diagnosis was polyp of the large bowel.

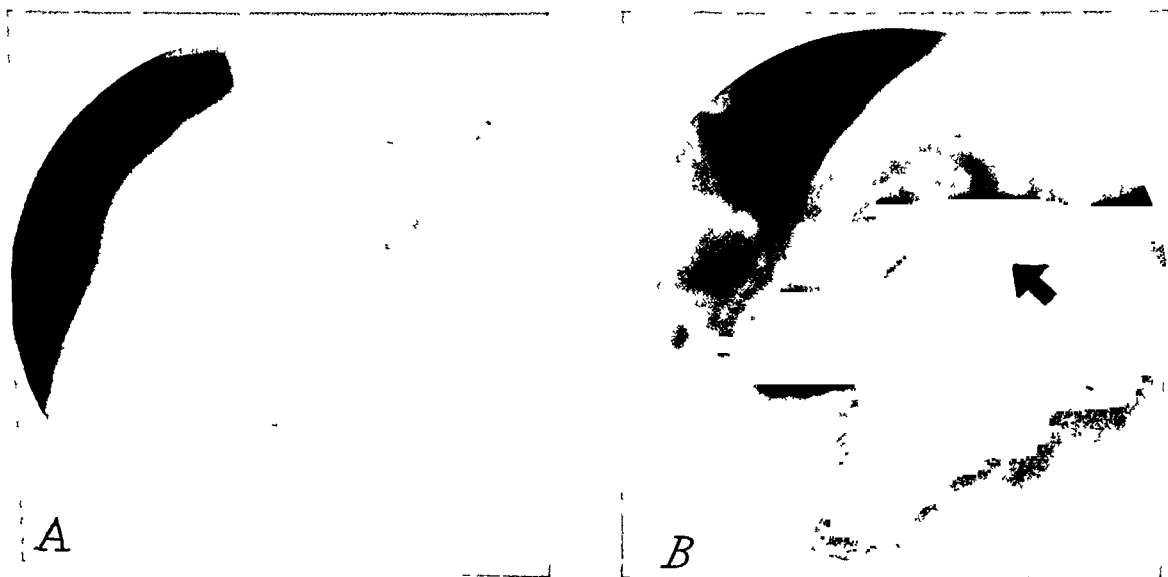


FIG. 9. Case VII. A, tumor is lost in shadow of the barium. B, polypoid tumor and its pedicle shown clearly with compression. Note dimpling (arrow) where stalk is attached to bowel wall.

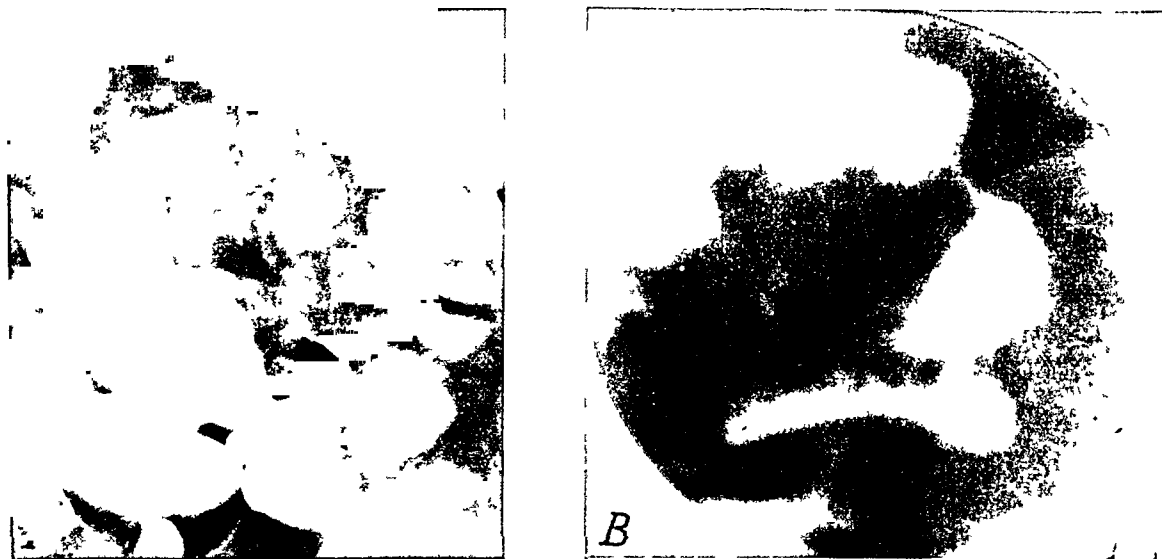


FIG. 10. Case VIII. Polypoid mass in sigmoid. *A*, routine barium enema. *B*, compression film.

CASE VIII. E. S. (HH 3502), a white female, aged seventy-two, was admitted complaining of lower abdominal cramps, nausea, vomiting and diarrhea of one day's duration. Her past history was not significant. The family history was non-contributory. The acute symptoms responded to medical treatment. During hospitalization a barium enema examination was done.

Single contrast study with pressure demonstrated a filling defect in the distal sigmoid on one side of the lumen (Fig. 10).

Sigmoidoscopy was not done. Surgical treatment was not carried out.

Comment. Case VI reflects our confidence in the puckering or dimpling criterion of diagnosis. Although a pedicle was not seen roentgenographically (there was none present), a second study was not considered essential. Note that small size is no indication of benignancy.

Among the cases reported in this series, only in this instance and in Case III were we requested to re-examine the patients at an interval after surgery. These 2 cases, when contrasted with the others, are the basis for the earlier statement that polypoid tumors with benign histopathologic reports do not receive the subsequent attention to which they are entitled.

We no longer feel that the second examination in Case VII was necessary. This also

serves to point out the frequency with which a dimple is noted at the base of the lesion.

Case VIII is included to indicate that we do not believe that we would be justified in advising surgery when we establish neither dimpling nor pedicle, nor a constant mass shadow.

Group IV: Complaints consistent with ulcerative colitis.

CASE IX. C. G. (EE 1955), a white male, aged fifteen, was admitted with the complaints of fever, loss of 20 pounds of weight, and nervous depression, all of two months' duration. There had been an increase in the number of bowel movements during the two weeks before hospitalization, but no blood or mucus had been noticed in the stools. The benzidine test was positive. Stool cultures and agglutination reactions were non-contributory. The patient was discharged to home care with the diagnosis of ulcerative colitis. Two months later he was re-admitted complaining of loose bloody stools with mucus. Weight loss had continued. Sigmoidoscopic examination was not done.

Single contrast barium enema examination five months following the onset of his illness showed an altered mucosal pattern, the appearance being that of multiple nodulations projecting into the bowel lumen. At the margins of the colon the contour was uneven but this was caused by negative shadows arising from the wall of the colon rather than by ul-



FIG. 11. Case IX. Routine barium enema showing multiple polyposis. (See text for description.)

cerations. No narrowing nor loss of haustrations was apparent. The terminal ileum was not visualized (Fig. 11).

The patient died eighteen months later.

Postmortem study showed the small intestine to be normal down to 50 cm. proximal to the ileocecal valve. In the remainder of the ileum there were numerous serpiginous ulcers

penetrating to the muscular layer. They measured from 1 mm. to a few centimeters in length; the bases were indurated. The mucosa between them was hypertrophic and in some areas formed pseudopolyps. The muscular coats and the serosa were normal. In the large intestine the mucosa everywhere was intact but there were hundreds of polyps. They were long and slender, measuring as much as 5 cm. in length. The pedicles were from 1 to 6 mm. in diameter; the bulbous tips were as much as 1 cm. across. Most of the latter were pink; some were black, and others were gray and necrotic. None showed any induration at the base. The wall of the intestine was normal (Fig. 12). The histopathologic diagnosis was chronic ulcerative ileitis and polyposis of the colon.

CASE X. E. G. (F 1684), a white female, aged forty-nine, was admitted complaining of diarrhea of eighteen months' duration. During this entire period it was intermittent except for the three weeks prior to hospitalization when it became severe and of daily occurrence. For a year the stools had been mixed and streaked with both bright red blood and mucus. There had been a 16 pound loss of weight and occasionally some mild cramp-like abdominal pain. The recorded family history was inadequate; the past history was non-contributory. Sigmoidoscopic examination showed eight to



FIG. 12. Case IX. Photograph of gross specimen of colon studied in Figure 11.



FIG. 13. Case x. Double contrast enema showing multiple polyposis.

ten polypi in the upper rectum and lower sigmoid varying from pin-head to pea size; two were pedunculated. All were fulgurated to a distance 9 inches above the anal canal.

Multiple polypoid lesions of the large bowel were demonstrated on two occasions, using

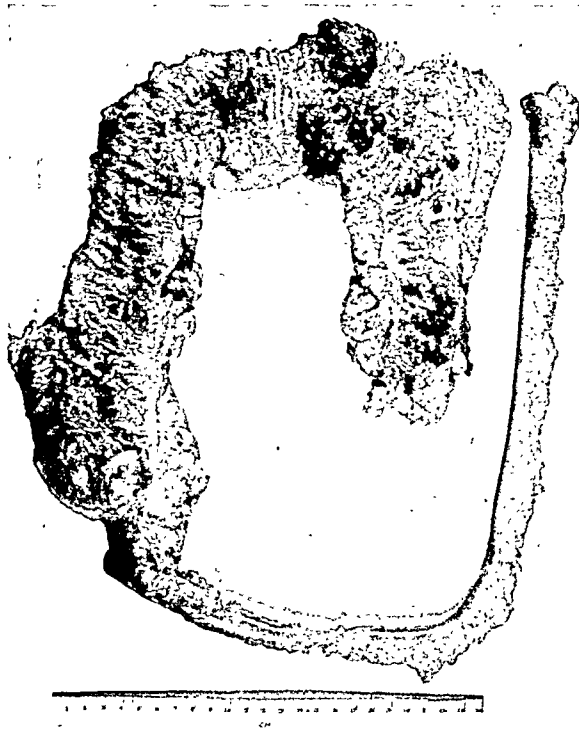


FIG. 14. Case x. Photograph of gross specimen of colon studied in Figure 13.

double contrast technique; stereoscopic films were made at the second examination (Fig. 13).

A portion of the ileum and the large bowel down to a point 4 inches above the rectosig-



FIG. 15. Ulcerative colitis, nonspecific. *A*, barium enema showing undermining ulcers (arrow). *B*, post-evacuation film exaggerating the polypoid character of the mucosal pattern.

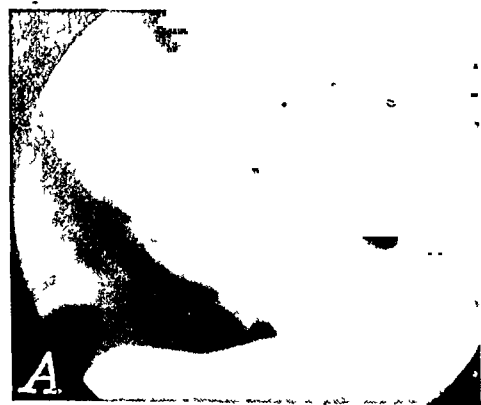


FIG. 16, A, B, C, D. Roentgenograms of various mucosal patterns in ulcerative colitis. Undermining ulcers with pseudopolyps between them (arrow). Note the marked resemblance of the pattern in D to that in Case IX, Figure 11 (multiple polyposis).

moidal junction were resected. Over the entire mucosal surface of the large bowel there were numerous pink and red polyps. The largest measured 4.0 by 2.5 cm. and was attached by a broad base. There were many pedunculated tumors measuring 2 cm. in diameter. The bowel wall was described as soft and pliable (Fig. 14). Microscopic sections showed malignant changes. Sections of mesentery showed metastases.

Comment. These 2 cases are illustrative of diffuse multiple polyposis. In one, the roentgenogram is that obtained in a single contrast type of examination; in the other, by double contrast study. Although the roentgen diagnosis occasionally may be made on the basis of the findings on the single contrast films, it is quite apparent

that the double contrast technique is superior.

For purposes of comparison and to present some roentgen features of another type of polypoid disease, roentgenograms of several cases of nonspecific ulcerative colitis are reproduced. In each instance severe diarrhea and bloody stools were the chief complaints and the proctosigmoidoscopic examination showed changes characteristic of ulcerative colitis. The roentgenograms chosen show those changes which simulate multiple polyposis (Fig. 15 and 16). There are two principal features. One is that of islands of mucosa, either normal or edematous, which project into the bowel lumen between ulcers and although they present a polypoid appearance are merely pseudo-

polyps. The second feature is actual polypoid formation, resulting from the piling up of mucosal shreds. Contributory roentgen evidence, particularly loss of haustrations and narrowing of the bowel lumen, should permit the differentiation from the familial type of multiple polyposis.

SUMMARY

Roentgenograms and some pathologic reproductions together with case histories have been presented illustrating four classes of polypoid disease of the colon, namely: the single lesion, the limited but multiple type, true multiple polyposis, and the polypoid manifestations in ulcerative colitis. These cases were grouped clinically as they presented themselves to the roentgenologist. The single contrast study, the double contrast study (with stereoscopy), and the roentgenoscopically controlled compression study have all been demonstrated. Pedicles and dimpling of the bowel wall at the site of attachment of the pedicle or of the mass itself have been demonstrated and discussed in reference both to diagnostic and surgical importance. Suggestions have been made to aid in the selection of one or more methods of roentgen study. The roentgenologist's responsibilities to both patients and colleagues have been discussed.

CONCLUSIONS

1. The demonstration of a pedicle or of dimpling of the bowel wall is sufficient for the diagnosis of a single polypoid lesion.
2. Surgery should not be advised unless the demonstration of either a simple filling defect in a single contrast study or a coated mass in a double contrast study can be reproduced.
3. All patients with sessile or pedunculated tumors should receive frequent follow-up studies to watch for recurrent tumor

regardless of the histopathology or the size of the surgical specimens.

4. Too much emphasis cannot be placed upon the need for careful and repeated study of the colon in cases of obscure bleeding.

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REFERENCES

1. BELL, J. C. Some uses of spot film in the roentgen-ray examination of the gastro-intestinal tract. *Radiology*, 1940, 34, 469-480.
2. FISCHER, A. W. Ueber eine neue röntgenologische Untersuchungsmethode des Dickdarms; Kombination von Kontrasteinlauf und Luftaufblähung. *Klin. Wchnschr*, 1923, 2, 1595-1598.
3. FISCHER, A. W. Ueber die Röntgenuntersuchung des Dickdarms mit Hilfe einer Kombination von Lufteinblasung und Kontrasteinlauf ("kombinierte Methode"). *Arch. f. klin. Chir.*, 1925, 134, 209-269.
4. JENKINSON, E. L., and WASKOW, W. L. Polyps of the large bowel. *Radiology*, 1940, 34, 489-498.
5. LAWRENCE, J. C. Gastrointestinal polyps; statistical study of malignancy incidence. *Am. J. Surg.*, 1936, 31, 499-505.
6. LUST, F. J. Roentgenological diagnosis of benign tumors (single polyps) of the colon. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1945, 54, 276-281.
7. OPPENHEIMER, A. Roentgen diagnosis of incipient cancer of the rectum. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1944, 52, 637-646.
8. SCHATZKI, R. Roentgenologic appearance of intussuscepted tumors of the colon, with and without barium examination. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1939, 41, 549-563.
9. SWINTON, N. W., and WARREN, S. Polyps of colon and rectum and their relation to malignancy. *J.A.M.A.*, 1939, 113, 1927-1933.
10. WEBER, H. M. Method for roentgenologic demonstration of polypoid lesions and polyposis of the colon. *Proc. Staff Meet., Mayo Clin.*, 1930, 5, 326-327.
11. WEBER, H. M. Roentgenologic demonstration of polypoid lesions and polyposis of the large intestine. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1931, 25, 577-589.



BERNHARD SCHMIDT AND HIS REFLECTOR CAMERA

AN ASTRONOMICAL CONTRIBUTION TO RADIOLOGY*†‡

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PAPER I

By PAUL C. HODGES, M.D.

Division of Roentgenology, The University of Chicago

CHICAGO, ILLINOIS

NOW that microfilming or photofluorography of the chest is firmly established in radiology with dozens of millions of examinations to its credit, it is inevitable that attempts will be made to extend the method to such fields as cerebral angiography and the roentgenography of the alimentary tract at repeated intervals. Such extension will become simple when it is possible to amplify the fluoroscopic image electronically, but until we are able to do this our only recourse is to strive for more brilliant photofluorographic screens, better films and faster lens systems.

Most chest microfilming is done at 90 kv., 200 ma., and a 42-inch target-screen distance, using screens that fluoresce either blue (zinc sulphide) or green (zinc cadmium sulphide) and films that are coated with excellent quality high speed green sensitive or blue sensitive emulsions. The two lenses in common use in this country are the Bausch and Lomb $f/2.0$ for 4 by 5 (Fig. 1) and the Eastman Kodak Ektar $f/1.5$ for 70 mm. films (Fig. 2), but even with these splendid refractors the exposure required is distressingly great. For a patient of average build the dose to the skin of the back is about $2\frac{1}{2}$ r for a 4 by 5 inch film and about 1.0 r for a 70 mm. film, whereas for direct filming on full size film the dose is only about $1/20$ r. It follows therefore that the best 4 by 5 camera commercially available today is only about $1/50$ th as efficient as direct filming, the best 70 mm. camera only about $1/20$ th as efficient. This inefficiency is not of serious importance in chest surveys but it does preclude repeated examinations

of the chest of a particular patient, to say nothing of repeated examinations of the abdomen where the dose will be multiplied by a factor of approximately 5.

A beginning has been made toward the production of more brilliant screens and a leading American manufacturer believes than an improved screen he has supplied us for experimental purposes* can be produced commercially, but for the present the most profitable source of greater speed seems to lie in following the lead of the astronomers and replacing our refractors by Schmidt type reflectors of the sort that have wrought such a revolution in the technique of sky mapping. Physicists, astronomers and television engineers are well acquainted with Schmidt reflectors; but in the belief that they will be new to most radiologists, several of us who have been working with them are preparing a group of five papers, of which this is the first.

In Paper II of the series, Professor George S. Monk of the Department of Physics of the University of Chicago under the title "Optical Systems for Photofluorography" discusses the aberrations that limit the work of the designers of refractors and shows why the Schmidt reflector provides a way around these limitations.

Paper III, "Two Danish Photofluorographic Cameras of the Original Schmidt Type" by Dr. Russell H. Morgan of the Department of Radiology at the Johns Hopkins Hospital and Dr. David M. Gould

* Since September, 1947, this screen has become available commercially as Patterson Type B2.

* The first in a series of five papers that are to appear in this JOURNAL.

† This paper was presented in part at the joint meeting of the Washington State Radiological Society and the Pacific Northwest Radiological Society, May 3, 1947.

‡ Supported by Navy Research Grant.

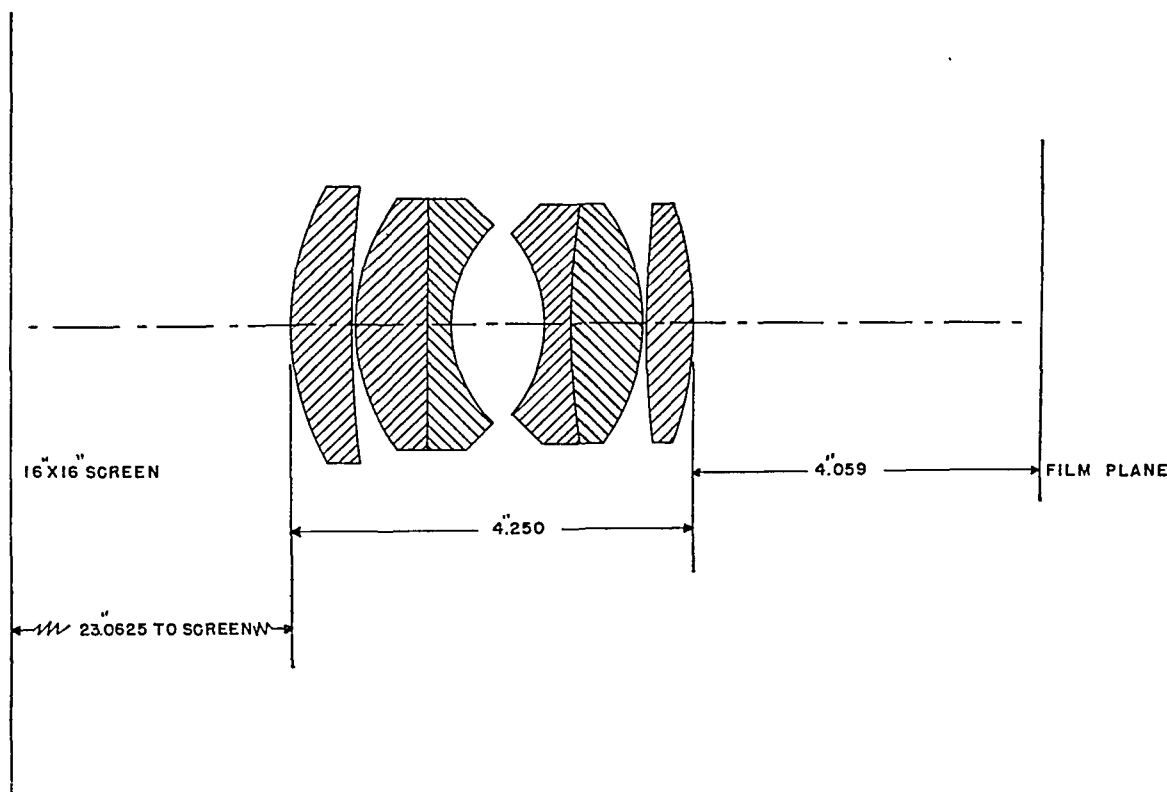


FIG. 1. Bausch and Lomb lens for 4×5 inch photoroentgenograms, speed $f/2.0$.

and Mr. Willard W. Van Allen of the U. S. Public Health Service, describes, illustrates and evaluates two instruments that were constructed by Helm and brought to this country recently at the instigation of Dr. Herman E. Hilleboe of the U. S. Public Health Service.

In Paper IV, entitled "New Types of Fast Cameras," Professor Louis G. Henyey and Professor Jesse L. Greenstein of the Department of Astronomy and the Yerkes Observatory of the University of Chicago describe a 35 mm. lens mirror system that they have designed for us and that has been constructed under their supervision in the Yerkes Optical Shop, and also an extremely fast 70 mm. system which is under construction at the present time.

In the final paper, Paper V, I shall describe the cameras we have built to utilize the Henyey-Greenstein lens mirror systems and the results of our work with them.

Reflecting telescopes are by no means new in astronomy. James Gregory devised one in 1663, Newton another type in 1671.

Cassegrain added his variation in 1672 and the technical contributions of the two Herschels date from 1774 and 1820. Since 1930 it has been necessary to add to this list of immortals the name of Bernhard Schmidt (Fig. 3), who was born March 30, 1879, on the little island of Nargen in Estonia and died December 1, 1935, in Hamburg, Germany.

Presumably the ardently nationalistic Estonian government of the period be

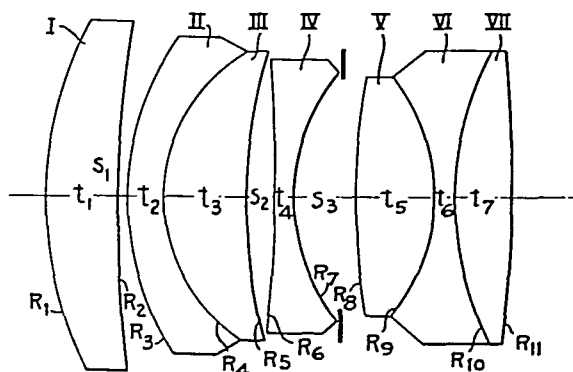
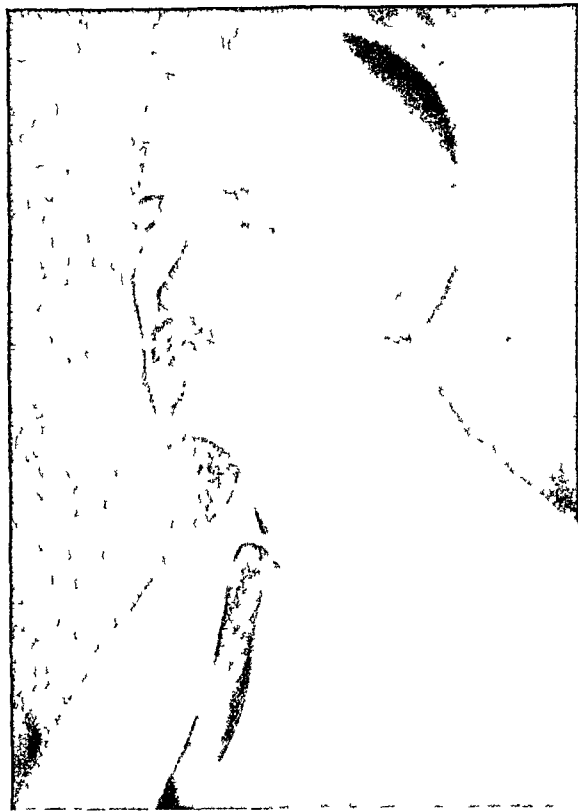


FIG. 2. Eastman Kodak Ektar lens for 70 mm. photofluorography, speed $f/1.5$.



BERNHARD SCHMIDT

FIG 3. Reproduction from Schorr's publication.³ The negative made by a Filipino photographer in 1929 was lost in the Japanese destruction of Manila.

tween the two world wars, if it existed today, would be glad to unearth and publish biographical material relative to Schmidt's boyhood, and possibly some of our radiological colleagues in Norway or Sweden may consider it worth while to hunt for traces of his student days in Gothenburg, Sweden; but the existing European and American literature dealing with optics based on Schmidt's great idea contains almost nothing about the man himself. There is one paper by Schmidt¹ and Mayall² has translated this together with Schorr's appreciation written shortly after Schmidt's death,³ but it is to Professor Walter Baade of the Mount Wilson Observatory⁴ that I am indebted for all of the intimate glimpses into the life of this man who has influenced so profoundly the optics of astronomy. Baade was associated with Schmidt inti-

mately at Bergedorf and on an eclipse expedition to the Philippines. He was an early convert to the Schmidt camera gospel and has preached that gospel faithfully since his arrival in the United States in 1931. It is probably true that the world owes the Schmidt camera largely to Schorr's insistence that Schmidt come to Bergedorf in 1926 but it is doubtful that the Schmidt principle would have had such prompt and wide acceptance in the United States without the constant urging of an astronomer of the standing of Baade. Professor Baade devoted a full day to me in Pasadena recently, during which we talked of the old days in Bergedorf and the Philippines, and since then he has loaned me photographs and sent copious answers to my written inquiries about various points in the Schmidt story.

Nargen is the Germanic name for an island known in the Estonian language as "The Island of the Women" (Fig. 4).^{*} It is only five miles long and about half as wide and lies in the Gulf of Finland at latitude $59^{\circ} 35' N$ and longitude $24^{\circ} 32' E$, twelve miles off the coast from Tallinn, Estonia, and about forty miles south of Helsingfors, Finland. A lighthouse at the northern tip, a light buoy at the southeast, a fringe of tiny villages—South Village, North Village, Rotten Harbor, Hayfield Village—and in the center fields and woods: that is Nargen as it appears on Estonian maps of 1929 and presumably much as it was in the late 80's and early 90's of Schmidt's boyhood. Twelve miles away across the Gulf lay Tallinn, even then a metropolis with good secondary schools, fine churches, old castles and a prosperous industry based largely on agriculture and shipping; but on the Island old customs and costumes prevailed and life centered upon the farms.¹¹ The Lutheran Church dominated the religious picture and though the grammar schools probably were better than many American rural schools of the same period,

^{*} I am indebted to Mr. Kalervo Rankama of the Department of Geology of the University of Chicago for translation of the legends on the map.

it is remarkable indeed that in this isolated environment a first-rate optical genius should have risen and developed.

Schmidt's Swedish mother and German father were deeply concerned with the religious training of their son in the Lutheran

faith, but their influence seems to have been not uniformly successful because on a certain Sunday morning when he was about eleven, young Bernhard, though dressed in his Sunday suit, was not in church but instead out in the fields trying

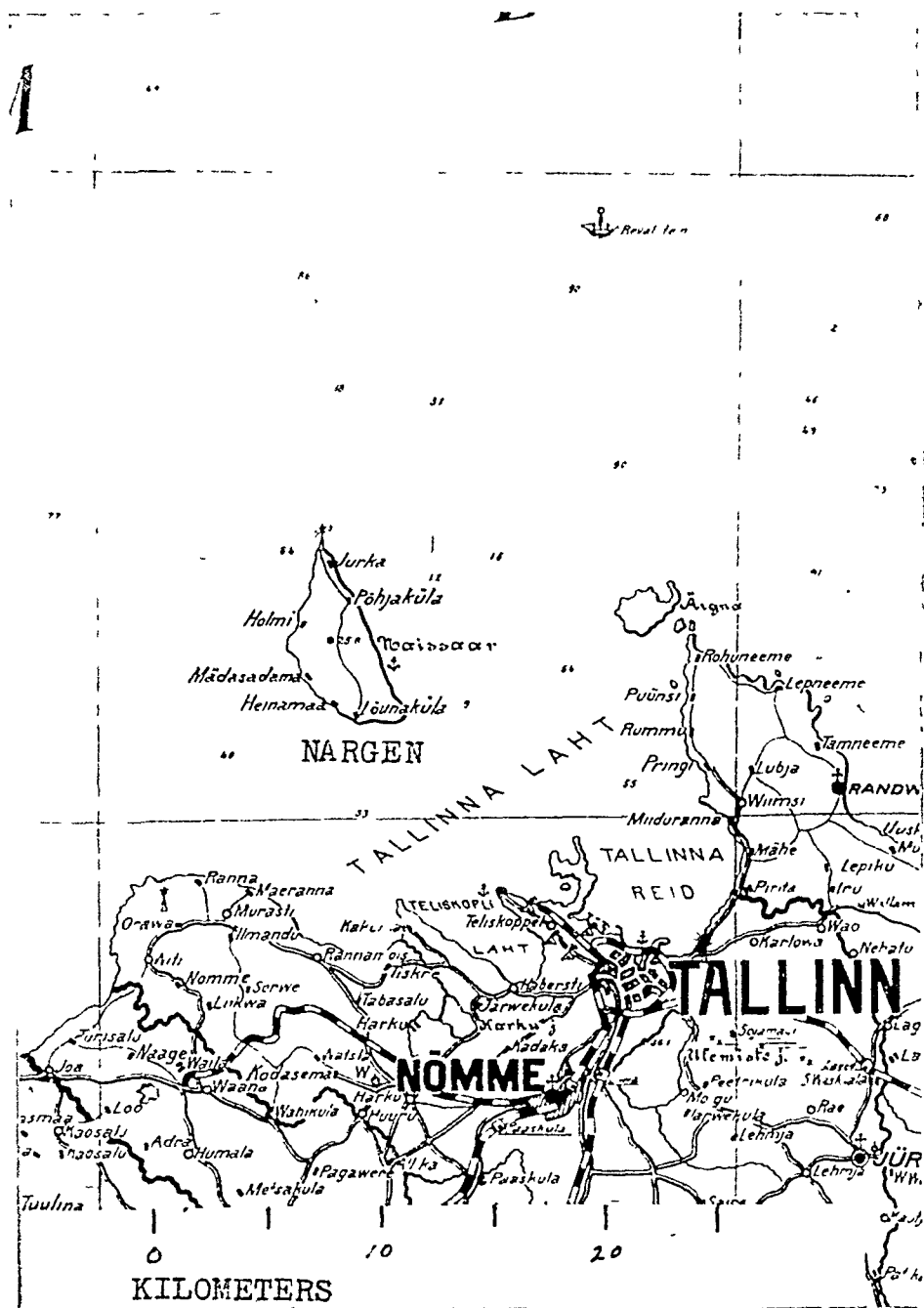


Fig. 4. Nargen Island, Estonia, birthplace of Bernhard Schmidt, from a map printed in Estonian and issued by the Ministry of Foreign Affairs in 1929. The island, five miles in length, lies in the Gulf of Finland twelve miles away from the Estonian capital, Tallinn.

out a batch of gunpowder of his own manufacture. He packed it into a piece of metal pipe to assure a good bang and the powder proved to be so good and the tamping so well done that when the explosion did occur it cost him his right hand and forearm. The boy was tough, however, and resourceful. He washed the stump in a brook, improvised a tourniquet and made it home unaided, apprehensive principally of anticipated parental wrath over a blood-drenched Sunday suit. Though this ended Bernhard's experiments in ballistics, it did not dampen his interest in mathematics and the physical sciences. From his friend the village druggist he obtained a few photographic plates and a description of a camera that the latter had once seen, and then using a cigar box and the bottom of a beer bottle that he had ground into a lens, built a camera and actually took pictures with it.

Toward the end of the century, Bernhard enrolled as an engineering student at the Institute of Technology at Gothenburg, Sweden, where he specialized in optics but, true to the tradition of his native land, scorned regimentation in any form. The library received most of his attention and here among other papers on optics he was particularly attracted by those of Dr. Karl Strehl, a physics teacher in a technological school in the little German town of Mittweida near Jena. That the Jena district was a veritable Mecca for those who were interested in optics in no small measure was due to the work and philanthropy of the great Ernst Abbe of the Zeiss optical works and the University of Jena. The son of a workman, Abbe was a devout believer in technical schools as instruments for the advancement of ambitious and intelligent workmen. After the death of Carl Zeiss in 1888, Abbe bought out Zeiss' son, Roderich, in order to convert the firm into a socialized enterprise and turned his own fortune over to the Carl Zeiss Foundation, retaining only an appointment as executive director of the Carl Zeiss Company at a fixed salary. The foundation subsidized technical schools in

the district about Jena and presumably the school in Mittweida was included in this program.

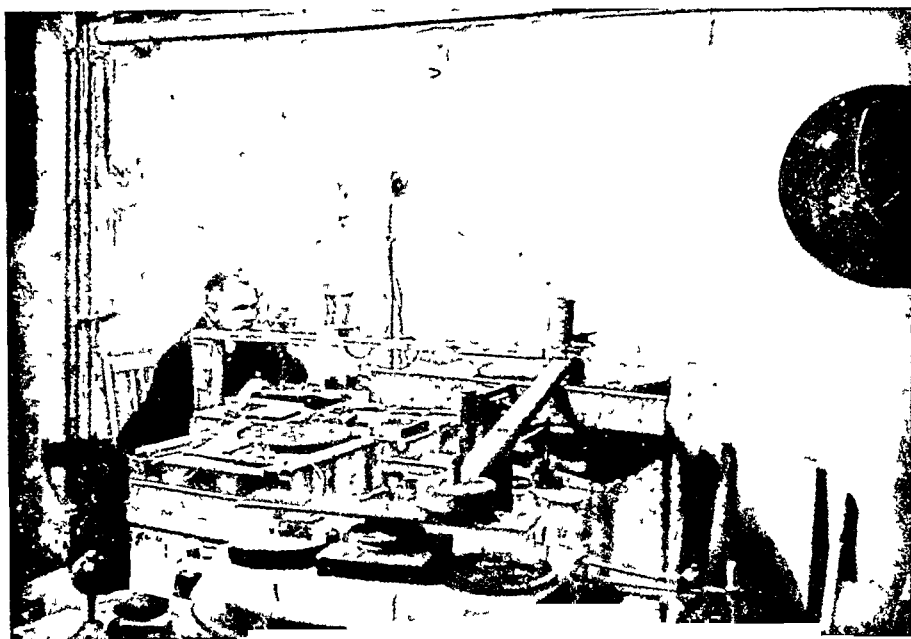
As soon as Schmidt could finance the trip, he traveled to Mittweida to seek out Dr. Strehl, only to find that the latter had moved away four years earlier. Apparently Schmidt liked the environment, however, because he stayed on in Mittweida for a quarter of a century, supporting himself by making mirrors and lenses and soon established a reputation as an unusually excellent source of small parabolic mirrors for amateur astronomers. Presently orders came from the professionals as well, and eventually Schmidt came to be recognized as one of the ablest of the German astronomical opticians.

But years and fame could not alter his social peculiarities. He scorned regular employment, including flattering offers from the great German optical houses, and accepted orders for mirrors and lenses only as the spirit moved him and always without guarantee as to delivery date. He was a bachelor and his wants were few. Simple lodgings, cognac, cigars, a little food and freedom from regimentation—these were all he asked; and even at the modest prices he charged, a few jobs each year supplied his needs. But though he was satisfied to work in this sporadic fashion, German astronomy was not satisfied, wanted more and more of the precise work that he was so peculiarly able to perform.

In 1920 Schmidt had made several mirrors for the Hamburg Observatory in Bergedorf and in 1926 Schorr, the director of that observatory, finally induced him to move to Bergedorf and share the living quarters of the younger unmarried astronomers. The arrangement was informal and Schorr describes Schmidt as a "voluntary colleague," an arrangement that avoided his intense distaste for restrictions on his hours of coming and going, working and rustication, and still gave the Hamburg astronomers first call on his work when, as and if he felt inclined to work (Fig. 5). Schorr deserves great credit for appreciat-

ing the importance of bringing Schmidt to Bergedorf and financing his stay there. To do this involved reckless breaking of rules with the risk at least of censure and perhaps even of punishment at the hands of government officials. To pay a stipend to an astronomer or a technician who worked regularly was one thing; but a stipend for a "voluntary colleague" who spent most of

made spherical rather than parabolic, the field angle would be wide and resolving power would be good, but the speed would be very low and the image would be focused on a spherical rather than a flat field. The spherical field was not too bad because it would probably be possible to warp the film to conform to the surface of a sphere but how to open up the stop in the



PRÜFEN

DES PHOTOGRAPHISCHEN OBJEKTIVES FÜR DEN 60 CM-REFRACTOR

FIG. 5. Schmidt at work in his Bergedorf laboratory. Reproduced from Schorr's article.³

his time roaming the woods and talking to himself, that was something decidedly different. It might have cost Schorr his job and his reputation but instead it gave the world the Schmidt telescope.

From the first years of his residence in Bergedorf Schmidt's mind was at work on the problem of overcoming the limitations of the reflecting telescope. Usually the mirror was parabolized by grinding away glass from its periphery. This allowed use of the full aperture and provided good resolving power for axial objects, but the field was extremely limited. If a diaphragm with a very small central opening was set up at the center of curvature and the mirror was

diaphragm, admitting more light and thus gaining speed without at the same time introducing spherical aberration? The answer to this question was Schmidt's great contribution to optics. Instead of a simple diaphragm opening or stop he decided to use a thin glass plate with an extremely shallow toroidal curve ground into one of its surfaces. Light transversing the center of this plate would pass to the mirror undeviated while that passing through the intermediate and peripheral zones would be deviated just enough to assure that on reflection by the mirror it would be focused sharply onto the spherically warped film. For practical purposes the results would be

the same as though a very small central stop had been used except that the light-gathering power of the system would be enormously greater.

From March to June, 1929, Schmidt accompanied Baade on an eclipse expedition to the Philippines (Fig. 6 and 7), and one evening when they were in the Indian Ocean told him that he had solved the problem of designing a coma-free reflector that would have good light-gathering power and wide field. He sketched the basic design and then the details of construction, possible forms of correcting plate, size of field, residual color, vignetting, etc., and it was evident that the whole thing had been thought out some time earlier—perhaps

even before leaving Hamburg. Baade urged that Schmidt plan to build such a reflector as soon as possible after returning to Bergedorf but the reply was that Schmidt must first think up an "elegant" way to grind the aspherical surface of the plate or in the vernacular of optics to "figure" it. To do it with small grinding tools Schmidt thought would be a sloppy job and would produce a plate that was full of zones.

After the expedition had returned to Hamburg, Schorr in his energetic fashion joined Baade in urging Schmidt to get on with the work but to no avail. Schmidt was unperturbed and continued as before on his seemingly aimless daily walks. Finally in the Winter of 1929-1930 he re-



FIG. 6. Sogod (Cebu), 1929, *Left to right, front row*: Colonel T. H. Robinson, Professor Walter Baade, Bernhard Schmidt. *Back row*: Unidentified, Mr. M. R. Cort. The group is sitting on the front porch of the American school in the little hamlet of Sogod at the northeast end of Cebu Island. Since it was vacation time, the American Commissioner of Education at Cebu had put the school yard and buildings at the disposal of the Hamburg expedition. The instruments were erected in the fenced yard and the buildings served as living quarters (Photograph courtesy Professor Baade.)

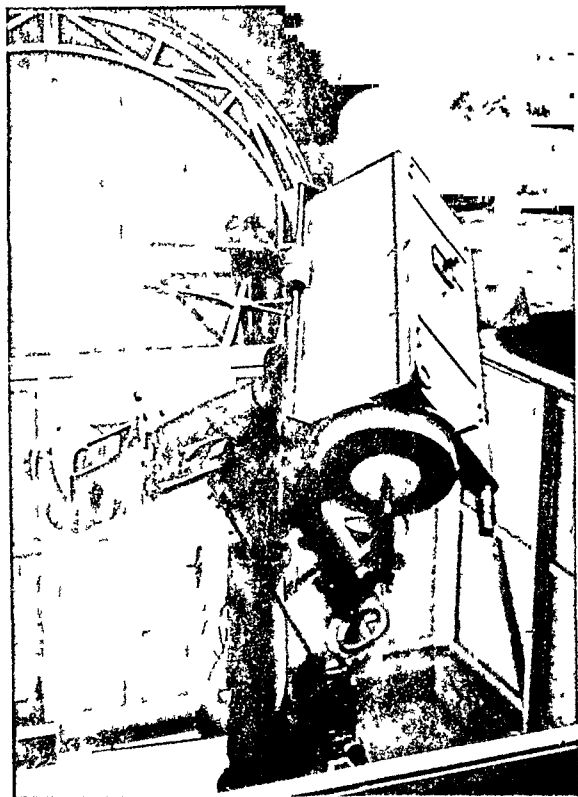


FIG. 7. Sogod, Cebu Island, 1929. Baade had given Schmidt full responsibility for the erection and adjustment of the astronomical instruments and with the aid of these three devoted Filipino assistants the work progressed in the smoothest possible fashion. His assistants became so devoted to Schmidt, whom they referred to as Professor Schmidt, that they wept when the work had been completed and it was necessary to decline their request to return to Hamburg with their "Professor." (Photograph courtesy Professor Baade.)

marked casually that he had at last devised an elegant solution for the figuring of the plate but for some of the details needed to consult a treatise on elasticity. Baade suggested the recently acquired "Handbuch der Physik" and after more than a week of library work Schmidt announced that he had found what he needed and was ready to assemble his grinding equipment.

There was a heavy metal pan of carefully calculated diameter and with its upper edge ground at a precise angle or bevel based on the coefficient of elasticity of the

particular glass plate that was being used and on the minute dimensions of the toroidal curve he wished to produce. The glass plate (of greater diameter than the pan) was sealed to the ground edge of the pan and then by means of a hand pump and manometer air was exhausted until a particular negative pressure had been developed. This caused the glass plate to warp slightly, the center being low, the glass over the edge of the pan high. Holding the plate in this position by maintaining a constant negative pressure, Schmidt



KOMAFREIER SPIEGEL SCHMIDT

VON 44 CM ÖFFNUNG UND 62.5 CM BRENNWEITE

FIG. 8. The original Schmidt telescope at the Hamburg Observatory in Bergedorf. Reproduced from Schorr's article.³

ground the upper surface until it was again plane, and then when the vacuum was released the plate sprang back until its bottom surface was plane, its upper surface slightly figured.

Baade remembers visiting the basement workroom one morning. Schmidt was napping briefly after thirty-six hours of uninterrupted work and on waking accepted cigars but declined coffee and sandwiches because though the plate now had the desired curve there was still the drudgery of obtaining the necessary polish. Twelve hours later the plate was finished and as predicted was free of zones.

Hendrix and Christie,⁵ who have reproduced Schmidt's night photograph of a windmill that stood near the observatory, are mistaken in describing it as the first

photograph made with the new camera. As a matter of fact, the camera went into operation early in 1930 and many dozens of stellar photographs were made in the following weeks and months. The windmill photograph, which was quite incidental, was made on a very cold winter night early in 1931 at a time when the Schmidt camera was about a year old. Schmidt's one and only publication appeared in 1932¹ and would not have appeared at all except for the loyal and diplomatic urging of his friends Schorr and Baade. Finally with the aid of the inevitable cognac, coffee, cakes and cigars he was induced to dictate the paper to Baade and after rewriting it for a last polish to give final approval to its publication.

In Schmidt's original camera (Fig. 8) the diameter of the correcting plate was 14.2 inches and that of the front surfaced mirror was 17.3 inches. The mirror had a radius of curvature of 49.2 inches and the speed of the system was $f/1.7$. Within a few years Hendrix had built several Schmidt cameras for the spectrographs on Mount Wilson and at present is completing a 48-inch correcting plate to be used with a 72-inch mirror on Mount Palomar. The smaller Schmidt, which has been in operation on Mount Palomar for ten years, has an 18-inch correcting plate that was made in the optical shop of the California Institute of Technology. Dimitroff and Baker⁹ have published Smiley's^{7,8} list of forty-four Schmidts built or building up to January, 1941, but consider the list incomplete even as of that date. Most, if not all, of the American correcting plates have been ground and polished by methods similar to those used in preparing spherical optical surfaces but the aspherical pattern makes the job difficult and each plate has required the close attention of an expert optician.⁶ It has been suggested that only by Schmidt's original method could mass production be established but not all lens makers accept this view and some contend that it cannot be used at all at small f numbers. Helm is

said to believe that he has discovered a method for producing plates for fast cameras at reasonable cost and in commercial quantities but has not disclosed the nature of the method. The molded plastic correcting plates that have served for certain applications of the Schmidt are generally considered unsuitable for photofluorography but even here there are certain optimistic dissenters.

The custom-built Henyey-Greenstein optical systems¹⁰ that will be described in Papers IV and V of this series are so extremely expensive that we could not have afforded to build them except for generous grants from U. S. Navy research funds, but if they prove to be practical they are adaptable to mass production at greatly reduced cost.

Prospective purchasers of conventional photofluorographs intended for routine chest surveys may be assured that present day refractors are well adapted to such work and that the practical extension of photofluorography to other fields of radiology is something for the future. When they do come, however—these all-purpose photofluorographs of the future—it is safe to assume that their optical systems will show the effects of Bernhard Schmidt's idea unless electronic amplification of the fluoro-

scopic image has been accomplished in the meantime.

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REFERENCES

1. SCHMIDT, BERNHARD. Ein lichtstarkes Koma-freies Spiegelsystem. *Mitteilungen der Hamburger Sternwarte in Bergedorf*, 1931-1932, No. 36, 7-15.
2. MAYALL, N. U. Bernhard Schmidt and his coma-free reflector. *Astronomical Society of the Pacific*, 1946, 58, 282-290.
3. SCHORR, R. Bernhard Schmidt. *Jahresbericht der Hamburger Sternwarte in Bergedorf*, 1935, pp. 15-18.
4. BAADE, WALTER. Mount Wilson Observatory, Pasadena, California. Personal communication, May 7, 1947.
5. HENDRIX, D. O., and CHRISTIE, W. H. Some applications of the Schmidt principle in optical design. *Scientific American*, August, 1939, pp. 118-123.
6. BAKER, J. G. Communication to A. G. Ingalls. *Scientific American*, 1939, 161, 314-317.
7. SMILEY, C. H. The Schmidt camera. *Popular Astronomy*, October, 1936, 44, No. 8.
8. SMILEY, C. H. The Schmidt camera. *Popular Astronomy*, April, 1940, 48, No. 4. (Contains an excellent bibliography.)
9. DIMITROFF, G. Z., and BAKER, J. G. Telescopes and Accessories. (Harvard Books on Astronomy), Blakiston, Philadelphia, 1945.
10. OSRD Report No. 4504. Wide Field Fast Cameras. 1945.
11. Estonian Yearbook. Bureau of Statistics, Tallinn, 1935.



THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Publisher: CHARLES C THOMAS, 301-327 East Lawrence Avenue, Springfield, Illinois.

Issued Monthly. Subscription \$10.00 per year, \$11.00 in Canada and \$12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 301-327 East Lawrence Avenue, Springfield, Ill. Information of interest to all readers will be found on page iv.

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INJURIOUS EFFECTS OF WHOLE BODY NEUTRON IRRADIATION IN ANIMALS

DURING the last decade considerable attention was paid to the relative injurious effects produced by the various types of ionizing radiations on animals when the whole body was exposed. The interest centered mainly on the action of the roentgen rays of different qualities and the gamma rays of radium. The numerous investigations included studies of the reactions of individual biologic systems, as, for example, the hemopoietic, lymphoid, gastrointestinal systems, etc., and the more violent responses of the entire organism, especially when large amounts of radiations were administered. The biologic data obtained were coordinated with physical factors of dosage and some very definite rules were established which are of great aid in the application of these radiations to the human.

With neutron rays the progress has been somewhat slower. Although the first neutrons were produced in 1932 the next ten years were taken up mostly with the development of adequate generating sources and the establishment of proper biologic criteria for medical use. Since 1938 a limited number of patients with cancer of various anatomic locations have been treated by the application of a direct beam of fast neutrons. Much of this early work was summarized in 1943 by Stone.¹ It was found that neutron rays act somewhat differently on tissue than do roentgen or gamma rays. Since the neutron carries no charge, it produces its biologic effect

mainly by setting in rapid motion recoil hydrogen nuclei (protons) and other light atomic nuclei. The ionization density of these particles being considerably greater than that of the electrons set in motion by the photons of the roentgen or gamma rays, most of the biologic reactions resulting from neutron irradiation are comparatively greater.

Aebersold and Lawrence² introduced an arbitrary unit of dosage of the fast neutron rays which they called the n-unit. For its measurement the Victoreen condenser type meter with the 100 r chamber is used. The procedure is the same as for the roentgen rays but 1 r on the scale is called 1 n. It is not easy to transfer this arbitrary unit, based on ionization of air by projection of oxygen and nitrogen, into a unit of tissue dose where according to the indications of Stone approximately 92 per cent of the absorbed energy of the fast neutrons is given to recoil hydrogen nuclei, 5 per cent to recoil oxygen nuclei, 2 per cent to recoil carbon nuclei and the remaining 1 per cent to other effects. The disintegration of nitrogen by the neutrons also complicates the issue. It was determined that to produce equivalent biologic reactions, the neutron rays, because of their greater ionizing power, are several times more effective in irradiating tissue than either the roentgen or gamma rays. From numerous measurements, Aebersold calculated that 1 n in tissue equals 2.5 neutron roentgens (with a 100 r Victoreen chamber) but the conversion factor may vary slightly with various tissues.

¹ Stone, Robert S. Neutrons: Therapy. In: Medical Physics. Otto Glasser, Editor. Year book Publishers, Chicago, 1944, pp. 812-816. Also: Stone, Robert S., and Larkin, John C., Jr. The treatment of cancer with fast neutrons. *Radiology*, 1942, 39, 608-620.

² Aebersold, Paul C., and Lawrence, John H. The physiological effects of neutron rays. *Ann. Rev. Physiol.*, 1942, 4, 25-48.

This relatively greater biologic efficiency of the neutron rays would seem to indicate that a correspondingly greater injury may also result to the individual biologic systems or the entire organism when the whole body is exposed. With the advent of mass production of atomic energy, in which neutron rays play a paramount role, an exploration of such a possibility became an urgent need.

A very valuable volume was published recently under the editorship of Dr. Ellice McDonald³ containing a series of articles written by the members of the Staff of the Biochemical Research Foundation. In these articles the authors deal with many important phases of the effects of neutron rays on the whole body of mice, rats, rabbits, chickens and dogs.

As McDonald states, the research on neutrons started at that institution some eight years ago with the availability of a cyclotron specially built for biochemical and biological study. During World War II, due to a request of the Manhattan District, the program was adapted to the plan of the Manhattan Project. This program made it necessary that the cyclotron produce neutrons daily at a given rate. According to the description of Enns, Terrill and Garner the cyclotron in question generated neutrons by the bombardment of a beryllium target with a deuteron beam of 9.5 mev. energy. The incidental gamma rays were filtered out by lead so that the radiation used for all experiments contained neutrons alone. The animals were placed in cages arranged around the target in such manner that simultaneous high and low dosage exposures were possible. The dose was expressed by following the above described method of Aebersold and Lawrence.

The present publication embodies the cooperative work of twenty-two scientists, whose untiring efforts led to some very notable contributions on the subject. Sev-

eral of the investigators made comprehensive studies particularly as regards the injurious effects of the neutrons, a problem of great importance to radiologists.

Leitch, for example, studied in extenso the relationship existing between neutron dose in whole body irradiation and the mortality, body weight and hematology of white rats. When large doses were given the effect was comparable to that of roentgen or gamma rays except that it was greater. A dose of 180 n proved lethal in six to eight days. Death was accompanied by extreme loss of weight and a maximum of leukopenia. If a dose of 60 to 120 n was given death occurred within two weeks although there was a beginning recovery from the leukopenia prior to death. A dose of 17.5 to 47.5 n remained harmless. The animals did not appear ill at any time and the slight leukopenia and weight loss disappeared rapidly. The most surprising thing, however, was that small repeated doses of neutron rays led to the formation of tumors in a rather high percentage of the animals irradiated. Doses of 1.8 n were given six days a week for seven months in one experiment and for nine months in two additional experiments. Throughout the period of observation repeated blood studies failed to show any significant difference between the irradiated and non-irradiated animals. There was some retardation of growth as indicated by the reduced body weight of the irradiated as compared to that of the non-irradiated rats and there was a slight roughness of the fur. But of greatest significance was the appearance of numerous tumors in the irradiated rats from 170 to 239 days after the start of irradiation or the administration of a cumulated dose of 263 to 369 n. Of 28 rats surviving for more than 150 days 11 showed various types of malignant tumors whereas in the sacrificed control rats no tumors or any pathologic changes were present in a single instance.

Leitch places considerable emphasis on the findings of tumor formations during and after the course of neutron irradiation in

³ Neutron Effects on Animals. Staff of the Biochemical Research Foundation. Dr. Ellice McDonald, Director, Newark, Delaware. Williams & Wilkins Co., Baltimore, 1947, pp. 198.

regard to the safety of radiologists since no concomitant hematologic changes were observed. This means that exposure to small doses of neutron rays over long periods of time may result in serious injury without there being the slightest forwarning from a study of the periodical check-up blood counts. Leitch also observed formation of tumors following the administration of twelve doses of 10 n but here it was preceded by severe hematologic changes indicative of neutron injury.

The behavior of the individual organs when the whole body is subjected to various doses of neutron rays was studied in several series of experiments by Ely, Ross and Gay. Attention was paid to the changes produced in testes, spleen, bone marrow, liver and kidneys of rats. The doses varied between 17.5 n, given in one day, and 113 n, given in two days. The testicular changes manifested themselves in the form of reduction of size, cessation of mitotic activity and atrophy of the germinal epithelium without injury to the Sertoli cells. The degree of the effect and the time of recovery were proportional to the dose given. The changes in the spleen consisted of a prompt reduction in size due to injury of the lymphoid tissue of this organ, the degree likewise depending on the magnitude of the dose. A return to an approximately normal status occurred even after a dose of 113 n. The liver and kidneys were found to be unaffected from a dose of 56.4 n, the only one given in this series. The bone marrow showed a temporary depression from the same dose. Ross and Ely also studied the effects of single and multiple doses of neutron radiation on the elements of the circulating blood, and of a single dose on the blood sedimentation rate. Leukopenia, lymphopenia and neutropenia were found to occur proportionately with increasing amounts of neutron irradiation from 11.3 to 113 n. The sedimentation rate increased gradually up to the eighth day after irradiation with 56.4 n, then it decreased slowly to normal. These experiments prove conclusively that the response of most

organs or biologic systems to neutron irradiation, when the whole body is exposed, is similar to that observed following irradiation with roentgen or gamma rays except for the already mentioned quantitative difference and the fact that neutron rays affect some tissues more selectively than others.

Ross and Ely in still another series of experiments studied the effect of massive doses of neutron rays on the whole body of dogs. They exposed four dogs to a total of 400 n given on four consecutive days. All dogs died within six to eight days. The clinical picture was very severe. Immediately after completion of the irradiation the dogs refused to eat or drink, they rapidly became dehydrated, cachectic and, just before death, developed a deep coma. There was marked coarseness of hair and skin, necrotic ulceration of the mouth, and severe subcutaneous hemorrhages with edema. The electrocardiograms showed a progressive myocardial damage, probably on an anoxic basis. The sedimentation rate rapidly rose as the animals approached death. The hematologic changes reached their peak on the fifth day when the maximum reduction of the white blood cells was 98.9 per cent, of the absolute neutrophils 99.2 per cent, of the absolute lymphocytes 97.9 per cent, and of the platelets 72 per cent. The reticulocytes had completely disappeared from the blood. At the same time the serum calcium, inorganic phosphorus, phosphatase and the total nitrogen content of the blood increased. Histopathologic studies after death revealed severe injury to the vascular system with extensive hemorrhages, complete destruction of the lymphoid tissue and pronounced injury to the testes.

Additional important studies by the various members of the Staff of the Biochemical Research Foundation included the reactions of *Escherichia coli* and *Euglena* to sublethal bombardment with neutrons, the reduced resistance of mice to infection with hemolytic *Staphylococcus aureus* when irradiated with as small a dose as 84.6 n,

the effect of neutrons on serum alkaline phosphatase; the action of neutrons on the peroxidase and catalase activity of the bone marrow; electrophoresis analyses of the blood plasmas of neutron irradiated rabbits, chickens and dogs; and other interesting problems.

McDonald modestly states that these investigations constitute only "a step to further research" but it is obvious that the value of the results already obtained is considerable. Irrefutable proof has been brought that a pure neutron source can produce a systemic effect which is much

more harmful than that produced by equivalent doses of roentgen or gamma rays, when the whole body is irradiated. In addition, there is the danger of inciting malignant tumor formation when small doses are given over a prolonged period of time. With the ever increasing use of atomic energy in medicine and industry, these are factors which must weigh heavily when considering adequate protective measures.

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SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY

Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Palmer House, Chicago, Ill., Sept. 14-17, 1948.

AMERICAN RADIUM SOCIETY

Secretary, Dr. H. F. Hare, 605 Commonwealth Ave., Boston, Mass. Annual meeting: Chicago, Ill., 1948.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1948, to be announced.

AMERICAN COLLEGE OF RADIOLOGY

Secretary, Mac F. Cahal, 20 N. Wacker Drive, Chicago 6. Annual meeting: Continental Hotel, Chicago, Ill., June 20, 1948.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION

Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: Chicago, Ill., June 21-25, 1948.

ALABAMA RADIOLOGICAL SOCIETY

Secretary, Dr. C. S. Stickley, 515 Bell Bldg., Montgomery, Ala. Next meeting time and place of Alabama State Medical Association.

ARKANSAS RADIOLOGICAL SOCIETY

Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

BROOKLYN ROENTGEN RAY SOCIETY

Secretary, Dr. A. H. Levy, 1354 Carroll St., Brooklyn 13, N. Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY

Secretary, Dr. Dwight V. Needham, 608 E. Genesee St., Syracuse, N. Y. Three meetings a year. January, May, November.

CHICAGO ROENTGEN SOCIETY

Secretary, Dr. T. J. Wachowski, 310 Ellis Ave., Wheaton, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY

Secretary, Dr. Eugene L. Saenger, 735 Doctors Bldg., Cincinnati 2, Ohio. Meets last Monday of each month, September to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY

Secretary, Dr. George L. Sackett, 10515 Carnegie Ave. Cleveland 6, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

DALLAS-FORT WORTH ROENTGEN STUDY CLUB

Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

DENVER RADIOLOGICAL CLUB

Secretary, Dr. Mark S. Donovan, 306 Majestic Bldg., Denver 2, Colo. Meets third Friday of each month at Department of Radiology, Colorado School of Medicine.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY

Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA RADIOLOGICAL SOCIETY

Secretary, Dr. J. A. Beals, St. Luke's Hospital, Jacksonville, Fla. Meets twice yearly, in April preceding annual meeting of Florida Medical Society, and in November.

GEORGIA RADIOLOGICAL SOCIETY

Secretary, Dr. Robert Drane, DeRenne Apartments, Savannah, Ga. Meets in mid-winter and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY

Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

ILLINOIS RADIOLOGICAL SOCIETY

Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY

Secretary, Dr. J. A. Campbell, Indiana University Hospitals, Indianapolis 7. Meets second Sunday in May.

IOWA X-RAY CLUB

Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

KENTUCKY RADIOLOGICAL SOCIETY

Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY

Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

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LOUISVILLE RADIOLOGICAL SOCIETY

Secretary, Dr. E. L. Pirkey, Louisville General Hospital, Louisville 2, Ky. Meets monthly on second Friday at Louisville General Hospital.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS

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Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

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Secretary, Dr. Chauncey N. Borman, 802 Medical Arts Bldg., Minneapolis 2, Minn. Two meetings yearly, one at time of Minnesota State Medical Association the other in the fall.

* Secretaries of societies not here listed are requested to send the necessary information to the Editor.

NEBRASKA RADIOLOGICAL SOCIETY

Secretary, Dr. Ralph C. Moore, Nebraska Methodist Hospital, Omaha 3, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

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Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

NEW YORK ROENTGEN SOCIETY

Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

NORTH CAROLINA RADIOLOGICAL SOCIETY

Secretary, Dr. J. E. Hemphill, 323 Professional Bldg., Charlotte 2, N. C. Meets in May and October.

NORTH DAKOTA RADIOLOGICAL SOCIETY

Secretary, Dr. C. O. Heilman, 807 Broadway, Fargo. Meetings held by announcement.

OHIO STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Carroll C. Dundon, 2065 Adelbert Road, Cleveland 6, Ohio. Next meeting at annual meeting of Ohio State Medical Association, Cincinnati, Ohio, March 31, 1948.

OKLAHOMA STATE RADIOLOGICAL SOCIETY

Secretary, Dr. P. E. Russo, 230 Osler Bldg., Oklahoma City, Okla. Three regular meetings annually.

OREGON RADIOLOGICAL SOCIETY

Secretary, Dr. William Y. Burton, 242 Medical Arts Bldg., Portland 5, Oregon. Meets monthly 2nd Wednesday, 8:00 P.M., Library of University of Oregon Medical School.

ORLEANS PARISH RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY

Secretary, Dr. S. J. Hawley, 1320 Madison St., Seattle 4, Wash. Meets annually in May.

PACIFIC ROENTGEN SOCIETY

Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY

Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport. Annual meeting, May 21-22, 1948, Erie, Pa., at Hotel Lawrence.

PHILADELPHIA ROENTGEN RAY SOCIETY

Secretary, Dr. C. L. Stewart, Jefferson Hospital. Meets, first Thursday of each month, October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY

Secretary, Dr. R. P. Meader, 4002 Jenkins Arcade Pittsburgh 22, Pa. Meets 6:30 P.M. at Webster Hall Hotel on second Wednesday each month, October to May inclusive.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY

Secretary, Dr. Harry A. Miller, 2452 Eutaw Place, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY

Secretary, Dr. Robert M. Lowman, Grace-New Haven Community Hospital, New Haven 11, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary.

RADIOLOGICAL SECTION, LOS ANGELES CO. MED. ASSN.

Secretary, Dr. Moris Horwitz, 2009 Wilshire Blvd., Los Angeles 5, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION

Secretary, Dr. Roy G. Giles, Temple, Texas.

RADIOLOGICAL SOCIETY OF NEW JERSEY

Secretary, Dr. Raphael Pomeranz, 31 Lincoln Park, Newark, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.

Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

Secretary, Dr. Maurice D. Frazer, 1037 Stuart Bldg., Lincoln, Nebr. Meets in Salt Lake City, Utah, 1948.

ST. LOUIS SOCIETY OF RADIOLOGISTS

Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September.

SAN DIEGO ROENTGEN SOCIETY

Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly, first Wednesday at dinner.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION

Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY

Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

SHREVEPORT RADIOLOGICAL CLUB

Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

SOUTH CAROLINA X-RAY SOCIETY

Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY

Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY

Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING

Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE

Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May inclusive. Room 203, Service Memorial Institute, 426 N. Charter St., Madison.

UTAH RADIOLOGICAL CONFERENCE

Secretary, Dr. Henry H. Lerner, School of Medicine, University of Utah, Salt Lake City 1. Meets 1st and 3rd Thursdays monthly from 7:30 to 10 P.M., Salt Lake County General Hospital, September to June.

UTAH STATE RADIOLOGICAL SOCIETY

Secretary, Dr. M. Lowry Allen, Judge Bldg., Salt Lake City 1, Utah. Meets third Wednesday in September, November, January, March and May.

VIRGINIA RADIOLOGICAL SOCIETY

Secretary, Dr. E. L. Flanagan, 116 E. Franklin St. Richmond, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Homer V. Hartzell, 310 Stimson Bldg., Seattle 1, Wash. Meets fourth Monday each month, October through May, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO

Secretary, Dr. Ivan J. Miller, 2000 Van Ness Ave. Meets monthly on third Thursday at 7:45 P.M., first six months of year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

CUBA**SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA**

President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

MEXICO**SOCIEDAD MEXICANA DE RADIOLOGIA Y FISIOTERAPIA**

General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

BRITISH EMPIRE**BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE ROENTGEN SOCIETY**

Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

FACULTY OF RADIOLOGISTS

Secretary, Dr. M. H. Jupe, 23 Welbeck St., London, W.1 England.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)

Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London.

CANADIAN ASSOCIATION OF RADIOLOGISTS

Honorary Secretary, Dr. E. M. Crawford, 2100 Marlowe Ave., Montreal 28, Que. Meetings January and June.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION

Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

SOCIÉTÉ CANADIENNE-FRANÇAISE D'ELECTROLOGIE ET DE RADIOLOGIE MÉDICALES

Secretary, Dr. Origène Dufresne, 4120 Ontario St., East, Montreal, P. Q.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION

Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS

Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION

Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

SOUTH AMERICA**SOCIEDAD ARGENTINA DE RADIOLOGIA**

Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

SOCIEDADE BRASILEIRA DE RADIOTERAPIA

Secretary, Dr. Andrelino Amaral, Av. Brigadeiro Luiz Antonio, 644, São Paulo, Brazil. Meets monthly on second Tuesday at 9 P.M. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

SOCIEDAD PERUANA DE RADIOLOGIA

Secretary, Dr. Julio Bedoya Paredes, Apartado, 2306 Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

CONTINENTAL EUROPE**SOCIÉTÉ BELGE DE RADIOLOGIE**

General Secretary, Dr. S. Masy, 111 Avenue des Alliés, Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.

CESKOSLOVENSKÁ SPOLEČNOST PRO RÖNTGENOLOGII A RADIOLOGII V PRAZE

Secretary, MUDr. Roman Blána, Praha XII, Korunní 160, Czechoslovakia.

POLISH SOCIETY OF RADIOLOGY

First post-war inaugural meeting will be held in Warsaw, May 22 and 23, 1947.

WARSAW SECTION, POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. L. Zgliczynski, Nowogrodzka 59, Warsaw, Poland. Meets monthly.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE

Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD. USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.

Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY

Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY

Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES

The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA

Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)

Secretary for French language, Dr. Babaianz, Geneva. *Secretary* for German language, Dr. Max Hopf, Effingerstrasse 49, Bern. Meets annually in different cities.

AMERICAN BOARD OF RADIOLOGY

Heretofore the American Board of Radiology has demanded that all candidates admitted to examination should be graduates of an approved Class A medical school. The Board has recently ruled, however, that those who have graduated from foreign and sub-standard medical schools before 1947 may be admitted to the examination if and when they have complied with the other requirements of the Board. No candidate who graduates from a sub-standard school (foreign or domestic) after 1947 will be admitted to the examination.

The Board has also ruled that a maximum credit of six months toward the required three years' training may be allowed for formal didactic courses in the basic sciences.

Many candidates who have applied for the entire field of Radiology or Roentgenology and who pass the examination in Diagnostic Roentgenology, or possibly the Therapy part of the examination, ask for a limited certificate in the field in which they have passed, expecting to re-apply shortly for the other field. This they are entitled to do but in order to discourage candidates taking partial certificates the Board has ruled that two years must elapse after a candidate accepts a certificate in one field before he may apply for additional certification.

B. R. KIRKLIN, M.D.

Secretary-Treasurer

American Board of Radiology

FINLAND NEEDS SCIENTIFIC BOOKS
AND PERIODICALS

Finland has an excellent and keenly scientific minded Technical Institute, Teknillinen Korkeakoulu. During the war its

library was bombed and totally destroyed.

On my recent trip to Finland for the American Friends Service Committee, I discussed the situation with Dr. Martti Levon, Director of the Institute. He said he would welcome gifts of Scientific and Technical Books and Periodicals from America to take the place of those destroyed. In the remarkable efforts for recovery that the Finns are making, the lack of technical library facilities is a very serious handicap. It would be a practical act of friendship to a nation that holds America in high regard if Americans should contribute good technical books and periodicals to this library.

Any such gifts should be marked for the Institute of Technology, Helsinki, and sent to the Legation of Finland, 2144 Wyoming Ave., N. W., Washington, D. C. Dr. K. T. Jutila, the Finnish Minister, will arrange for their being shipped to Finland.

ARTHUR E. MORGAN

Member, American Friends

Service Committee

Yellow Springs, Ohio

POSTGRADUATE COURSES

The American College of Radiology and the Philadelphia Roentgen Ray Society will conduct Postgraduate Courses in Philadelphia from February 2 to 6, 1948. The meetings will be held in the Philadelphia County Medical Society Building, 301 South 21st St. The courses are available to members of the American College of Radiology and there is a fee of \$50.00. Application must be made in advance by writing to the American College of Radiology, Postgraduate Courses, 20 North Wacker Drive, Chicago 6, Illinois.



DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., B.S., M.A., 103 Rutledge Ave.
Charleston, S. C.

INSTRUMENTS USEFUL IN CASES OF TRISMUS*

By HAYES MARTIN, M.D.
Attending Surgeon, Memorial Hospital
NEW YORK, NEW YORK

JAW EXERCISER†

TRISMUS is a condition characterized by an inability to open the mouth. It may be complete or incomplete and is invariably accompanied by pain. In the treatment of cancer of the mouth by radiation therapy, surgery, or both, trismus

The instrument which is here illustrated (Fig. 1) may be used by the patient to pry the jaws apart manually. In addition, an elastic force is provided by an adjustment so that the jaws may be allowed to ease themselves gently toward each other, closing the mouth. In this way, the instru-

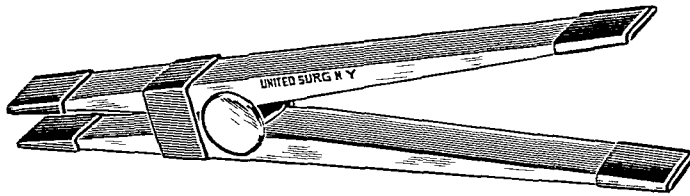


FIG. 1. Jaw exerciser.

may develop during or at the termination of treatment, or even some months or years later. It is frequently associated with irradiation or post-surgical scarring of the pterygoid muscles or partial disuse ankylosis of the temporomandibular joints due to pain. Such a complication is serious because it interferes with proper alimentation and culminates in a situation where satisfactory oral hygiene, indispensable for the healing of intra-oral tissues already handicapped by previous injury, is difficult if not impossible.

ment assists in *exercising the jaws* which is so essential in breaking up adhesions in the temporomandibular joints and in restoring the tone of the unused atonic muscles of mastication.

JAW STRETCHER†

In performing intra-oral operations where marked trismus is present, the instrument illustrated in Figure 2 assists the surgeon in manually prying and maintaining the jaws apart. It consists of two par-

* From the Head and Neck Service, Memorial Hospital.

† This instrument is manufactured by and may be purchased from the United Surgical Supplies Co., New York. Figures 1 and 2 are reproduced through the kindness of the United Surgical Supplies Co.

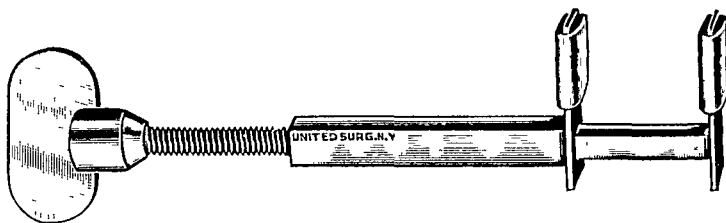


FIG. 2. Jaw stretcher.

allel metal plates attached to a steel handle. By turning the screw in a clockwise manner the space between the metal plates increases and in this way forcibly opens the

mouth. The plates are covered with rubber to prevent injury to the teeth or gums.

737 Park Ave.
New York 21, N. Y.



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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

HENDERSON, S. G., and SHERMAN, L. S.
Roentgen anatomy of the skull in the newborn infant. *Radiology*, Feb., 1946, 46, 107-118.

A series of 100 healthy newborn infant skulls, aged one to fourteen days, were examined roentgenologically to learn more of the normal and of normal variations. Posteroanterior, lateral, occipital, mentovertical and maxillary sinus positions were used in all cases. In addition, lateral mastoid positions were made in approximately one-fourth of the infants studied.

Some points of interest were: A large number of brachycephalic skulls, with linear index above 80, were found, presumably due in part to molding of the head during labor. No direct relation could be found between the size of the newborn skull and the body birth weight. Separation of the cranial bones was found to vary greatly. The cartilaginous portion of the occipital bone forms a more acute angle with the base of the skull anteriorly than the case of the adult, averaging 112° in the newborn. Various miscellaneous findings, including the incidence of posterior fontanelle bones, and of anomalous occipital centers of ossification, presence of vascular markings and of apparent convolutional impressions, mastoid development, nasal accessory sinuses, congenital deflection of the nasal septum and deformities of the skull due to prenatal causes and to molding in labor were noted.

The authors review the embryological development of the skull and present a table outlining the pertinent facts regarding the manner in which each bone develops.

They list the measurements of the sella turcica, the various skull diameters, the degree of separation of the cranial bones, the angle between the squamous portion of the occipital, the superior nuchal line and the base of the skull anterior to the occipital squama. Average diameters in millimeters for sella turcica were: anteroposterior, 5.2; depth, 2.5; average skull diameters in centimeters were: anteroposterior, 12.5; vertical height, 10.18; breadth, 10.2.

A number of labeled roentgenograms are shown for identification of anatomical parts.—*F. B. Markunas.*

HAMILTON, L. C., and THOMPSON, PAUL E.
Treatment of cryptococcic meningitis with penicillin. *Am. J. Dis. Child.*, Sept., 1946, 72, 334-342.

The case of the patient reported in this paper is the third under ten years of age for whom a diagnosis of cryptococcic meningitis has been reported. On roentgen examination, the pneumoencephalogram showed evidence of increased intracranial pressure. The ventriculogram showed well marked dilatation of both lateral ventricles. The examination of the chest revealed pneumonic infiltration probably due to the *Cryptococcus neoformans*.

All forms of treatment used in this disease have failed more times than they have succeeded. Patients for whom therapy has been successful have usually been those with slow progress of the disease, in whom the causative strain of the organism was apparently of relatively low virulence. With the use of penicillin clinical results were far from gratifying, but quantitative cultural results seem to suggest that it may destroy *C. neoformans* in vivo. Further studies will be necessary to establish the most effective plan to maintain relatively high concentrations of penicillin in cerebrospinal fluid.—*R. S. Bromer.*

O'KEEFE, JOHN J., and CLERF, LOUIS H.
Malignant tumors of the maxillary sinus; an analysis of 47 fatalities. *Ann. Otol., Rhin. & Laryng.*, June, 1946, 55, 312-321.

The diagnosis of malignancy of the paranasal sinuses all too often is made during the late stages of the disease. This is due in great measure to the fact that patients suffer the presence of tumor masses of the face, paresthesias, dental pain, and infraorbital pain for prolonged periods, before seeking medical care. Another reason, and an alarming one, is the degree of procrastination played, both by the physician and by the patient, before definite therapy is instituted.

This summary is a study of 47 such cases observed in the Radium Clinic of the Philadelphia General Hospital. When initially presented, all showed evidences of extension of the primary antral disease, and in spite of intensive and variously combined forms of therapy, all resulted in death.

Incidence and Symptoms. Males generally are more frequently observed with carcinoma of the sinuses, and in this study there were 33 males to 14 females, or a proportion of 70.2 per cent male to 29.8 per cent female.

The age distribution is of wide variation, but the highest incidence occurs in the age groups between fifty to seventy years.

The duration of the patients' chief symptom, when first seen, varied from one month to twenty-eight years and all complained of multiple symptoms prior to seeking medical care. In the order of frequency, palpable swelling of the face or bulging of the eye, was the most frequent complaint. This was followed by pain in the face or teeth.

Classification. Ohngren has projected a line onto the antrum, extending from the inner canthus of the eye to the angle of the jaw, thereby bisecting it obliquely into superior and inferior divisions. Another line, dropped vertically through the center of the antrum, further subdivides these areas into medial and lateral halves. Those cases listed as being present for more than one year have had their origin in the dormant or slow growing area—the lateral part of the superior division. Those present for less than a year were faster growing and originated in the medial part of the superior division and in the inferior division.

Treatment. Newer methods of treatment are securing better results in selected cases. The combined use of electrosurgery with irradiation, offers the best chance of cure; protracted fractional external irradiation is a valuable supplement.—*Mary Frances Vastine.*

HEATLY, CLYDE A. Adamantinoma of the maxillary sinus with report of two cases. *Ann. Otol., Rhin. & Laryng.*, June, 1946, 55, 322-333.

Adamantinoma occurs far more frequently in the mandible than in the maxilla. Involvement of the maxillary sinus by this tumor is uncommon in the experience of most rhinologists.

1. Adamantinoma may be defined according

to Robinson as "an epithelial tumor arising from the odontogenic apparatus or from cells with a potentiality for forming tissues of the enamel organ."

2. The adamantinoma may be described as a central tumor, slow and intermittent in its growth, anatomically benign but clinically persistent. Macroscopically two types are recognized, the solid and the cystic. Most authorities agree with Kronfeld that the adamantinoma is originally a solid growth and the cystic variety represents a later degenerative process occurring within the epithelial strands of the tumor.

3. Adamantinoma may occur at any age.

4. The diagnosis is suggested by the slow, frequently painless development of the tumor, by the absence of evidence of soft tissue invasion, by the crackling sensation which can commonly be elicited on palpation over prominent portions of the tumor, by the usual absence of regional glandular involvement (exceptions to this have been pointed out), and finally by the roentgenogram in which the multilocular cystic arrangement of the bony shell and trabeculae is characteristic.

5. Regarding the prognosis, the adamantinoma must be regarded as a slow-growing expansive tumor with a strong tendency to recurrence.

6. Treatment: (1) The likelihood of recurrence will be lessened by the removal of the bony antral walls where possible, as well as by the meticulous use of coagulating current. (2) The early detection of recurrence will be aided not only by the creation of a large antral window but also by maintaining the opening in the canine fossa for a long period. (3) The value of postoperative irradiation is distinctly limited in view of the radioresistant nature of this tumor.—*Mary Frances Vastine.*

NECK AND CHEST

VIOLE, PIERRE. Schwannoma of the pharynx. *Ann. Otol., Rhin. & Laryng.*, June, 1946, 55, 334-341.

Among other relatively rare developments, schwannoma of the pharynx takes a prominent place as an interesting example of benign tumor. Though this growth is not limited to the head and neck, these are the areas more frequently involved.

In a recent review of the subject by Ehrlich

and Martin, covering a six year survey at the Memorial Hospital in New York City, only 23 cases were encountered. In almost half of these the tumor was located in the head and neck, the neck being by far the most frequent seat of the new growth. Since it is conceded to be a tumor of nerve origin, this frequency of occurrence in the cervical area is believed to be due to the presence of extensive peripheral nerve trunks in the neck.

Incidence. Age and sex seem to have no recognizable bearing on the occurrence of this growth.

Diagnosis. Aspiration biopsy is recommended as being less hazardous than operative biopsy. Diagnosis cannot be established clinically; histologic study must be the determining diagnostic procedure.

Pathology. These tumors invariably are found to be encapsulated, are usually smooth of surface, globular in form, though sometimes nodular, and, unless degeneration of the tumor tissue has occurred, are found to be firm and fibrous. When located in the neck, the tumor is usually anterior to the carotid artery and beneath the upper one-third of the sternocleidomastoid muscle. The tendency is to force the artery outward, with the tumor growing inward.

Treatment. In common with all tumors of nerve origin, these schwannomas are markedly radioresistant, and irradiation is contraindicated. Sufficiently small doses of radiation to be harmless are ineffectual, and intensified treatment may cause damage to adjacent tissues. Surgical removal may be resorted to as a means of relieving mechanical pressure due to the growth, or for psychological or cosmetic reasons where the size of the growth has become sufficient to produce disfigurement. It does not metastasize, and from experience in surgical excision no recurrence is reported. However, where the mass is still small and the patient is suffering no marked discomfort, but is apprehensive regarding surgery, removal may be deferred indefinitely without risk, as progress of the growth will undoubtedly be slow and threat of malignancy unlikely.—*Mary Frances Vastine.*

TURCHIK, FRANK. Schwannoma of the pharynx with paralysis of the vocal cord. *Arch. Otolaryng.*, Nov., 1946, 44, 568-573.

A case of schwannoma of the pharynx is

reported, with its point of origin definitely located in the vagus nerve at its exit from the jugular foramen. This case, plus 2 other cases (Hill and Nigro), showed unilateral paralysis of the vocal cord. Schwannomas are rare tumors in the pharynx, attain a large size and cause extensive damage by pressure. Only 7 cases have been reported in the literature. Accurate elicitation and evaluation of the signs and symptoms preoperatively should permit an early diagnosis of this lesion prior to its appearance in the pharynx. Early operation utilizing the safer external approach, lateral pharyngotomy, advocated by Orton, should eradicate the tumor and avoid the troublesome complications so frequently encountered.—*Mary Frances Vastine.*

BRUNSCHWIG, ALEXANDER, and LINDSAY, JOHN R. Further experiences with panlaryngectomy for advanced carcinoma of the larynx. *Surg., Gynec. & Obst.*, Nov., 1946, 83, 639-642.

This report is prompted by the continued very pessimistic attitude generally existing in regard to advanced or extrinsic laryngeal carcinoma, especially when there have been recurrences following more conservative procedures and/or when there has been a failure of control following radiation therapy. While the series of patients here considered is not a very large one it would appear that after failure of the more conservative operative procedures or radiation therapy, there is still something to offer these patients if the process has not extended beyond the neck.

A larynx, the site of recurrent and advanced cancer, is the source of considerable distress which is often not greatly ameliorated by simple tracheotomy. Its wide resection constitutes a palliative measure, to say nothing of offering an opportunity for "cure," which experience has shown cannot be afforded by other means.

Summary. Further experiences with panlaryngectomy have substantiated the view that the procedure is indicated in advanced carcinoma of the larynx and in recurrences following more conservative surgical procedures or radiation therapy which has failed to control the process.

The procedure affords the opportunity for appreciable palliation and also for prolonged

control of the disease (seven years in one case in the reported series).—*Mary Frances Vastine.*

DANZER, JOSEPH T. Roentgenograms of the chest in mental deficiency. *Radiology*, March, 1946, 46, 244-249.

In the interpretation of chest films of feeble-minded patients one must know whether the inmate is a moron, imbecile, or idiot, since the amount of lung markings present in a healthy moron's chest is no different from that of a healthy normal individual. However, in the low grade imbecile and idiot, there is a marked increase in perivascular infiltration, with mottled areas of congestion. Some explanation for these increased markings may be a very high cough threshold and the very sedentary lives led by these patients. Deformities of the thoracic cage, lack of muscular development, and unusual habits such as air swallowing, are additional factors which help obscure the diagnosis in chest conditions. There is a lack of resistance of these patients to tuberculosis, especially when the patient is from a family of neuropathic stock. The average survival for all cases after tuberculosis has been found to be two months.

At this date the author feels a statement regarding pneumonia as cause of death in feeble-minded patients is difficult to make because cardiac conditions of congenital origin and epilepsy complicate the study of the chest in pneumonia.—*F. B. Markunas.*

PIERSON, W. M. Aplasia of the lung. *Ann. Otol., Rhin. & Laryng.*, Sept., 1946, 55, 604-608.

The positive diagnosis of a case of true aplasia of the lung by roentgen examination, bronchoscopy and bronchography in an infant eight months of age appears to be sufficiently rare to justify its presentation.

Most authors have accepted Schneider's classification of agenesis of the lung as follows:

- (1) True aplasia of the lung and bronchus in which there is no trace of a bronchus.
- (2) Aplasia of the lung in which the bronchus is represented by a blind pouch or a nodule of cartilage and fibrous tissue.
- (3) Extreme hypoplasia of the lung in which the main bronchus is normal in size and shape and ends in a fleshy structure.

Absence of a lung does not forecast an early death. There have been cases reported in which the individuals were aged fifty-eight, sixty-five and seventy-two years, respectively; all died of causes unrelated to the agenesis of the lung. The symptoms are variable and in many cases are absent, the condition being discovered only accidentally when for some reason, such as a general physical examination, the subject has had a roentgenogram of the chest. Dyspnea, cyanosis and a failure to thrive may be noted in the very young. The external symmetry of the thorax is maintained in most cases of true aplasia of the lung and bronchus. Apparently filling of the potential space by the displaced mediastinal contents and a portion of the hypertrophied contralateral lung at an early stage of the development prevents contraction of the affected hemithorax. The heart and the mediastinal contents are displaced to the affected side and the apical impulse of the heart is pronounced. Dullness or flatness on the affected side is common but there may be resonance because of the hypertrophy and the emphysema of the remaining lung. The breath sounds may be absent or suppressed.

The usual roentgen interpretation is massive or fetal atelectasis.—*Mary Frances Vastine.*

PRICE, ALISON H., and TEPLICK, GEORGE, Progressive bilateral bullous emphysema. *Arch. Int. Med.*, Feb. 1946, 77, 132-142.

The paper is a report of 8 cases that were seen in the Jefferson Hospital during a period of three years.

In the upper pulmonary fields the walls of the bullae replace the normal markings by a patternless tracery of fine linear shadows. Confluence of some bullae and discreteness of others cause great irregularity of size and shape. In some instances they are high and cyst like, replacing the upper lobe; in others, they are numerous and small; and in far advanced cases the upper lobes are compressed. The lower pulmonary fields usually show the markings of interstitial fibrosis. The thorax appears lengthened because of the depressed diaphragm, which draws the mediastinal tissues with it. Bronchography in 2 patients showed great depression of the bronchi of the upper lobes by the bullae.

It is the opinion of the authors that this condition is more prevalent than the literature suggests.—*James J. McCort.*

GOLD, MICHAEL M. A. Congenital dilatation of the pulmonary arterial tree; relation to Ayerza's disease and primary pulmonary arteriosclerosis. *Arch. Int. Med.*, August, 1946, 78, 197-209.

The author gives the criteria for isolated congenital dilatation of the pulmonary artery. These are: (1) dilatation of the entire pulmonary arterial tree with or without sclerosis; (2) hypoplasia of the aorta; (3) the absence of other congenital anomalies, such as patent ductus arteriosus or patent interauricular septum; (4) the absence of other primary disease of the heart of lungs and of primary arterial disease such as rheumatism or syphilis. When these criteria are applied to the cases reported in the literature under the name "congenital dilatation of the pulmonary artery" only 4 cases meet the requirements.

A case is presented which showed at necropsy a dilated arteriosclerotic pulmonary tree and a hypoplastic aorta. The relationship to Ayerza's disease and to primary pulmonary arteriosclerosis is discussed.—James J. McCort.

WRIGHT, D. O., and GOLD, EDWIN M. Löffler's syndrome associated with creeping eruption (cutaneous helminthiasis). *Arch. Int. Med.* Sept., 1946, 78, 303-312.

The authors had previously reported 9 cases of transitory, migratory, pulmonary infiltration with peripheral eosinophilia and paucity or absence of systemic manifestations, fulfilling the criteria of Löffler's syndrome. (Wright, D. O., and Gold, E. M. Loeffler's syndrome associated with creeping eruption (cutaneous helminthiasis). *J.A.M.A.*, 1945, 128, 1082-1083.)

During the summers of 1943 and 1944 they observed 76 cases of creeping eruption believed to be due to *Ancylostoma braziliense* because typical linear burrows were present in the skin in each of these cases. It was possible to study 52 of these cases for fourteen days or longer. During this period of study, in 26 of the 52 cases there developed transitory, migratory, pulmonary infiltration and peripheral eosinophilia, with almost complete absence of clinical signs or symptoms of systemic disease.

The patchy pulmonary infiltration did not usually appear before the seventh day of the cutaneous eruption. When the cutaneous lesions were untreated the pulmonary infiltrations continued on a migratory course over a period

of weeks. The areas of infiltration varied in size from isolated parenchymal lesions to approximately 75 per cent of the pulmonary fields. Cavitation was not seen.—James J. McCort.

RYTAND, DAVID A., and LIPSITCH, LESTER S. Clinical aspects of calcification of the mitral annulus fibrosus. *Arch. Int. Med.*, Nov., 1946, 78, 544-564.

The primary purpose of this paper is to present observations made during the lives of 10 elderly patients with calcification of the mitral annulus fibrosus. None had a history of rheumatic fever and there was no convincing evidence of rheumatic heart disease in 3 necropsies. Atherosclerosis was marked; calcification of the large arteries to the neck was found in 2 patients at necropsy.

Congestive heart failure occurred in 5 patients, angina pectoris in 2 only. Arterial hypertension was present in practically every case but was not often severe.

Five patients had complete heart block. This was paroxysmal in 2, while partial block in a third was temporarily made complete by digitalis. Four of these patients, but only 1 of those without block, have died.

In 7 patients there was a moderate or a loud, rough murmur with ventricular systole. The significance of the murmurs is not clear, but they were not regarded as evidence either of mitral regurgitation or of mitral stenosis.

The authors conclude that calcification of the mitral annulus fibrosus may be suspected in elderly persons after the finding of heart block and an apical murmur associated with auricular activity during ventricular diastole.—James J. McCort.

GENITOURINARY SYSTEM

PREHN, D. T. A pyelographic sign in the diagnosis of perinephric abscess. *J. Urol.*, Jan., 1946, 55, 8-17.

The diagnosis of perinephric abscess is at times difficult. The mortality in diagnosed cases approximates 20 per cent. Trauma to the kidney, especially the right, is an important predisposing factor. Even more important is a history of preceding skin infections such as pustules, carbuncles, cellulitis, etc. Osteomyelitis and upper respiratory infections are also potential causes of perinephric abscess.

Fever, pain in the loin, tenderness to loin percussion, mild rigidity and tumefaction are

among the commonest signs and symptoms. Among the important roentgen findings on the survey film are; (1) obliteration of the lateral border of the psoas muscle shadow; (2) obscuration of obliteration of the kidney shadow; (3) obscuration of the ribs or spinal transverse shadows; (4) curvature of the spine with convexity on the healthy side; (5) presence of the shadow of the abscess; (6) displacement of the colon by the abscess; and (7) fixation or limitation of the motion of the diaphragm.

Additional signs revealed by intravenous and retrograde pyelography are (1) renal fixation as revealed by films in the Trendelenburg, horizontal and vertical positions; (2) anterior displacement of the kidney as shown by lateral film; (3) outward displacement of the kidney and medial displacement of the ureter, and (4) rotation of a calyx in the pyelogram.

The author reports a case in which the only positive roentgen finding was a 90 per cent anterior rotation of the superior calyx of the upper pole of the kidney due to a large perinephric abscess in the upper perirenal fat.—*Rolfe M. Harvey.*

KLEEBERG, J., and DREYFUSS, F. Value of x-ray examination in non-surgical diseases of the kidneys. *Radiol. clin.*, Nov., 1946, 15, 323-334.

The authors believe that not enough attention is paid to roentgen examination in purely medical diseases of the kidneys. The taking of plain roentgenograms without contrast has proved invaluable to them in both diagnosis and prognosis. A follow-up of the size of the kidneys is extremely valuable in prognosis in chronic glomerulonephritis and in high blood pressure. They found in their cases that as kidney function deteriorated the kidney shadows became smaller. In cases with a slower and more benign course the size of the kidneys might remain unchanged for years. In the acute stage of hematogenous glomerulonephritis no roentgen shadows of the kidneys could be obtained, as the gas-filled bowels rendered the kidney region invisible.

A differentiation can be made between the rare interstitial, septic and usually fatal type of acute nephritis and the usual form of acute glomerulonephritis by the fact that in the former disease the kidneys are visible and markedly enlarged. Clinically and biochemically these two diseases are very much alike.

Typical cases of these diseases are described and illustrated with roentgenograms.—*Audrey G. Morgan.*

ABESHOUSE, BENJAMIN S., and WEINBERG, TOBIAS. Malignant renal neoplasms. *Arch. Surg.*, Jan., 1945, 50, 46-55.

A series of 63 consecutive proved cases of malignant renal neoplasms is presented. In this series 90.5 per cent were parenchymal tumors and 9.5 per cent were malignancies involving the mucosa of the renal pelvis and calices. Metastases occurred most commonly to the lungs, bones, and liver, regional lymph nodes, adrenal glands, opposite kidney, heart, brain, and in 2 cases to the operative scar.

The most common clinical symptom was hematuria. This occurred as a chief complaint in 35 per cent of the patients. Pain was the initial symptom in 16 per cent of the cases. A palpable mass was the initial symptom in 2 patients. The duration of symptoms was extremely variable and difficult to evaluate. Other less common symptoms include localized tenderness over the mass, loss of weight, elevated temperature, bladder symptoms, gastrointestinal symptoms, and anemia.

The authors recommend roentgenographic studies, including a survey film and retrograde pyelography, supplemented by intravenous urography in some cases. A brief discussion of the differential diagnoses on the roentgenographic findings is included. Their preoperative diagnosis was correct in 65 per cent of the cases. An analysis of the cases in which an incorrect preoperative diagnosis was made showed that 5 of these patients had concomitant renal lesion such as stones, cysts, and abscesses in addition to their tumor. The other 13 were errors in the preoperative diagnoses.

The operability of a renal tumor should be based upon: (1) penetration of the tumor through its capsule, (2) presence of perirenal tumor infiltration, (3) abnormal fixation of the tumor in the renal bed, (4) presence of secondary metastatic deposits in the perirenal and juxta-aortic lymph nodes or in the intra-abdominal organs, and (5) presence of tumor thrombi in the renal veins and the inferior vena cava.

A satisfactory evaluation of roentgen therapy is not given in this series.

Twelve of 44 patients in this series were living

and well five years following operation. This is a five year survival of 35 per cent.

The best results were obtained in those patients who had hypernephroma. The results were less satisfactory in those patients with primary carcinoma of the renal pelvis.—*George W. Chamberlin.*

LINDBOM, ÅKE. Fornix backflow in excretion urography; its significance in the differential diagnosis of tuberculosis of the kidney. *Acta radiol.*, 1943, 24, 411-418.

In retrograde pyelography the contrast medium sometimes extends from the pelvis and is visualized in the roentgenogram as a shadow extending into the substance of the kidney. This pelvirenal backflow may have two different explanations: (1) the contrast medium has penetrated up into the renal tubules in which case it is a so-called *pyelocanalicular backflow*, or (2) there may be a rupture in the pelvis which is almost always at the fornix of a calyx. This type of backflow might therefore be called *fornix backflow*. Sometimes the contrast medium which has passed through a rupture of this type goes into the renal veins which are then visualized in the roentgenogram—*pyelovenous backflow*. The lymph vessels may also become filled with the contrast medium—*pyelolymphatic backflow*.

Much has been written on backflow in retrograde pyelography but backflow in excretion urography has received little attention.

The author's investigations:

1. Technique for routine urographic examinations—a film was exposed five minutes after the injection of the contrast fluid. Compression was then applied over the ureters for twenty to twenty-five minutes during which period two or three films were taken.

2. The investigation comprised 2,600 cases in 900 of which compression had been applied and the quality of the films was such that it was possible to determine whether or not backflow was present. In 15 of these cases (1.6 per cent) a definite fornix backflow was visualized. By way of comparison it may be mentioned that the number of cases of early renal tuberculosis in the same material was 9 (1 per cent).

3. It is often impossible to make a definite distinction in the roentgenograms between a sinus extravasation and cavities due to tuberculosis. However, in sinus extravasation a free zone is usually seen between the contrast-filled kidney calyx and the extravasated mass of fluid. In addition to this, the irregular shadow

of the extravasated contrast solution' often changes its size and configuration during the course of the urographic examination: In those ruptures of the fornix appearing at a late stage, a normal roentgenogram was often obtained before the rupture had occurred. This, of course indicated that it was due to extravasation and not to tuberculosis. On the other hand, it is conceivable that a preformed cavity in the renal parenchyma does not necessarily fill until the renal pelvis is widely distended.

4. When uncertainty is felt as to whether the shadows are due to backflow or to a tuberculous condition a guinea-pig test is recommended. A more certain and probably a quicker way of deciding the question is to make another urographic examination, or possibly a retrograde pyelogram, in a week or so. A rupture in the fornix may then have had time to heal and a normal picture will then be produced.

5. It must be remembered that an obstructing ureteral calculus may have the same effect as compression in excretion urography.—*Mary Frances Vastine.*

PRICE, PHILIP B. Experience with calculus of the bladder in North China. *Arch. Surg.*, Feb., 1945, 50, 82-86.

In certain parts of China, calculus of the bladder is endemic. This report concerns 126 patients with vesicle calculus seen in Shantung Province. Seventy-four per cent of the patients were between the age of five and fifteen years and only 7 per cent were more than twenty-five years old. There is some evidence to suggest that many of these patients may have vitamin deficiency. Most of the stones were radiopaque but 2 patients had nonopaque stones. Renal calculi were rarely observed. Some of the bladder calculi were multiple, but the usual finding was a single large calculus. Four of the patients had obstruction of the vesicle outlet. Two of these had an obstructive phimosis. One had a traumatic stricture of the membranous urethra and 2 had urethral strictures following gonorrhea. The routine treatment was suprapubic lithotomy following preoperative preparation which consisted largely of restoring the patient's fluid and electrolyte balance, and of general nursing care.—*George W. Chamberlin.*

BLOOD AND LYMPH SYSTEM

LYSHOLM, ERIK. Radiological circulation measurements. *Radiol. clin.*, May, 1946, 15, 144-164.

Roentgenological measurement of the circu-

lation may be carried out by the method of absorption or that of radiation. In the former method an absorptive substance is injected into the blood and when it has reached the point to be examined it is recorded by the increase in the absorption of roentgen rays, either on a film or with some suitable instrument. In the second method a radioactive substance is injected and the time of its arrival determined by recording the radiation.

Experiments in recording the circulation roentgenologically have been going on at the Seraphimer Hospital in Stockholm for the past ten years. In showing the vessels after injection of the contrast medium they have used a cassette changer by means of which several pictures can be taken in rapid succession, and have also used both direct and indirect roentgen cinematography. Concentrated contrast media were used with these methods, which are not without danger to the patient. Therefore absorption determinations were made with photocells and counter tubes and the use of diluted contrast media. Tests with Na^{24} have been made, combined with electrocardiographic recording. These have proved accurate with points at a distance from each other, as for arm to arm or arm to leg on the same side, but not accurate for points lying close together, as two points in the heart. Some preparation with a softer radiation than that of Na^{24} is therefore indicated; Br^{82} is such a preparation but it has not been obtained of sufficient power for tests on man. An iodine isotope, I^{131} , has also been tested but it will require further experimentation to show whether it can be produced in sufficient concentration for the tests. No experiments have been made with beta radiators (active phosphorus).—*Audrey G. Morgan.*

DRUSS, JOSEPH G. Aural manifestations of leukemia. *Arch. Otolaryng.*, Oct., 1945, 42, 267-274.

The author has reviewed the medical records of 148 subjects with leukemia admitted to the Mount Sinai Hospital over a period of five years. Particular attention has been paid to the aural involvement in these cases and a detailed study of 4 patients who died has been made. Histopathologic examination of a temporal bone on each of these 4 cases was made. The author's summary and conclusions are as follows:

1. Aural complications of leukemia are more prevalent than is generally believed. They oc-

curred in 25 of the 148 cases reviewed, or in 16.8 per cent. Routine examination of the ears including functional tests of the cochlear and vestibular nerves would undoubtedly disclose an even greater incidence.

2. The aural complications include diseases of the external, the middle and the internal ear and of their adnexa.

3. The pathologic changes in the ear, as elsewhere in the body, are comprised chiefly of hemorrhage, cellular (leukemic) infiltration and inflammation.

4. Pathologic changes in the ear may be revealed on histopathologic examination even in cases in which there was at no time during the illness any clinical evidence of aural disease.

5. Otitic infections are comparatively more severe in the leukemic than in the non-leukemic patient; they not infrequently show a strong tendency toward early invasion of the adjacent structures.

6. The diagnosis of acute mastoiditis in a leukemic subject may paradoxically be made more difficult by the presence of postauricular swelling and sagging of the bony external canal wall, since these signs, so well recognized as pathognomonic of suppuration in the mastoid bone, may under such circumstances also represent leukemic infiltrations in the adjacent soft parts.—*Mary Frances Vastine.*

GENERAL

COSTELLO, CYRIL J. Breast cancer and "Paget's disease of the breast." *Arch. Surg.*, Nov-Dec., 1945, 51, 262-278.

This article presents a review of 29 patients with Paget's disease of the breast and a discussion of the nature, derivation, and treatment of this disease.

Patients with Paget's disease frequently complain of intractable eczema of the nipple and areola. Excoriations occur and crusting may follow. In the 29 cases presented, 22 were between the ages of forty and seventy and none were less than thirty years of age. Fifty-nine per cent had a palpable mass in the breast in addition to the cutaneous lesion. The characteristic part of the lesion on histological study is the presence in the epidermis of the areola of a large neoplastic cell which is called the "Paget cell." These cells are not supposed to arise from the epidermis. The author states that it is necessary to differentiate the histological picture in Paget's disease from that seen in Bowen's disease, superficial epitheliomatosis,

simple eczema of the nipple and squamous cell carcinoma of the breast. The different features of the histological appearance of these lesions is presented.

In the 29 patients presented in this series, it was found that adenocarcinoma of the breast was present in every case in which the diagnosis of Paget's disease of the breast was made histologically. It was also noted that the Paget's cell presented an identical histological appearance with the cancer cells found in the underlying carcinoma. According to the author, it is inadequate, however, to explain all such intradermal metastatic malignant cells on the basis of a single type of lesion, since it has been shown that they may occur from other types of carcinoma, from epithelioma, from melanoma, from apocrine gland carcinoma, and possibly other primary lesions. He feels that the use of the term "Paget's disease" should be abandoned and in its place the use of the term "secondary epidermal carcinoma" is suggested.

The treatment for these lesions is early radical mastectomy, whether or not a primary site of tumor growth can be palpated in the breast.—*George W. Chamberlin.*

LÜBSCHITZ, KAREN. A case of plasma cell mastitis. *Acta radiol.*, 1943, 24, 403-410.

Plasma cell mastitis seems to be quite rare. It has a marked resemblance to breast cancer.

Patho-anatomic and histologic picture—first described by Ewing in 1925. There is a more or less well delimited tumor-like process in the mammary tissue in the form of solid strands of close connective tissue. In between these, numerous dilated milk ducts and alveoli containing a creamy grayish mass are seen. Small necrotic foci are noted and often there are yellowish, xanthomatoid points. A characteristic microscopic feature is the presence of an inflammatory exudate which, as a rule, consists chiefly of plasma cells. In the dilated milk ducts there is proliferation of the epithelium. Giant cells are formed here by a fusion of the cells and they are usually seen to contain fat. Also there are xanthomatoid cells containing lipid masses.

Thus it is seen that histopathologically the condition represents an inflammatory process which is of the chronic or subacute order since there is no tendency to abscess formation and the productive element is more pronounced than in ordinary mastitis.

Course of the disease. Little is known about this because so far all the cases have been operated upon, most of them under the mistaken diagnosis of cancer. However, two of Adair's cases, which had been correctly diagnosed as plasma cell mastitis, were followed for two years before operation was done, and during this time no change occurred in the process.

Prognosis. Thus the prognosis must be said to be good and the affection benign. There is nothing to indicate that plasma cell mastitis is a precursor of cancer. However, the proliferation of the hyperchromatic epithelial cells in the lactiferous ducts which is supposed to be the result of a chemical irritation of lipid split products might seem to place the affection in the precancerous group.

Differential Diagnosis. Carcinoma of the breast; chronic lactation mastitis; traumatic fat necrosis; tuberculous mastitis; syphilitic mastitis.—*Mary Frances Vastine.*

FREEMAN, SMITH, RHOADS, PAUL S., and YEAGER, LEONA B. Toxic manifestations associated with prolonged ertron ingestion. *J.A.M.A.*, Jan. 26, 1946, 130, 197-202.

The authors present 2 cases of toxic reaction to prolonged ingestion of large doses of a commercial vitamin B preparation called ertron. Although the hazards of vitamin B overdosage in the treatment of arthritis are well known, the manufacturers of this product have consistently denied serious toxic effects from its use.

Both of the reported patients received doses of ertron ranging from 100,000 to 300,000 units per day for various periods totalling many months. Renal insufficiency was the primary serious injury produced by the incident metabolic change, the degree of renal impairment being marked in both cases.

A conspicuous finding in 1 of the cases was widespread calcification in the soft tissues. Metastatic calcification is one of the characteristic findings in animals poisoned with vitamin D and the kidney is frequently the site of these deposits. Numerous studies have demonstrated that the absolute as well as relative amounts of calcium and phosphorus in the diet influence the toxicity of vitamin D. Both of the intoxicated patients presented in this report gave a history of the consumption of 1 to 2 quarts of milk a day.

The effect of ertron on the calcium balance of a nine year old white male patient treated for

arthritis was also presented. This study revealed an increase in the urinary excretion of calcium while the patient was receiving ertron on the low and the high calcium diets. Ertron reduced the fecal excretion of calcium on the low calcium diet and increased the fecal loss of calcium while the patient was on a high calcium diet. While this patient was on the high calcium diet he developed an albuminuria which cleared up one week after ertron administration was discontinued. Studies on animals have shown that large doses of vitamin D reduce calcium retention, as evidenced by decalcification of the bones, even to the point of causing spontaneous fractures.

The authors concluded that large doses of vitamin D in the treatment of arthritis is a dangerous practice; that the maintenance of a constant calcium and phosphorus intake simplifies the problem; that the amount of milk and calcium-rich food products should be controlled. Large doses of vitamin D from any source are potentially toxic and this toxicity can be explained as due to its effect on calcium and phosphorus metabolism and kidney function. The renal insufficiency occurring in the 2 cases was apparently the result of these changes.—*Charles B. Cobern.*

ROENTGEN AND RADIUM THERAPY

CHAPMAN, EARLE M., and EVANS, ROBLEY D.

The treatment of hyperthyroidism with radioactive iodine. *J.A.M.A.*, May 11, 1946, 131, 86-91.

Twenty-two patients with classical thyrotoxicosis who were seen in the Massachusetts General Hospital were treated with radioactive iodine and no other simultaneous or subsequent form of therapy. Two patients were improved but still have mild hyperthyroidism. Four patients developed myxedema. The others all had normal basal metabolic rates during follow-up periods up to three years. All patients had enlarged thyroids at the beginning of the study, and all but one presented a normal or barely palpable gland after the treatment.

The radioactive iodine used was prepared by deuteron bombardment of tellurium which produced a mixture of I^{130} and I^{131} . The average dose was 40 to 50 millicuries, but one patient received a total dose of 147 millicuries. Doses were calculated to provide about 0.5 to 1.0 millicurie of I^{130} for each estimated gram of thyroid tissue. An attempt was made to calcu-

late the dose in roentgens, and in one patient a dose of 14 millicuries was found to be equivalent to about 3,490 roentgens.

Some of the patients developed nausea, vomiting, malaise, and even slight increase in gland size with fever; this resembled the usual acute roentgen sickness. Most of these patients had received large doses.

Several of the patients had been unsuccessfully treated by other means, such as operation or by usual roentgen irradiation. One patient was sensitive to thiouracil and to iodine in the usual dosage; this patient was successfully treated with radioactive iodine. None of the patients was treated concurrently nor subsequently with the usual form of iodine, and most of them were prepared for the treatment with low iodine intake regimens.—*E. F. Lang.*

HERTZ, SAUL, and ROBERTS, ARTHUR. Radioactive iodine in the study of thyroid physiology. VII. The use of radioactive iodine therapy in hyperthyroidism. *J.A.M.A.*, May 11, 1946, 131, 81-86.

Twenty-nine patients with hyperthyroidism who were seen in the Massachusetts General Hospital were treated with radioactive iodine. This report presents the results after the patients had been followed for three to five years. The iodine used was a mixture of I^{130} and I^{131} , and the total therapeutic dosage varied between 0.7 and 28 millicuries. The patients were followed clinically for a prolonged period, and particularly during the administration of non-radioactive iodine, which was given immediately after a course of treatment with radioactive iodine. This was given to each patient for two reasons: (1) non-radioactive iodine either does not affect normal excretion of radioactive iodine from the thyroid or tends to prevent its excretion; (2) uncontrolled thyrotoxicosis might be harmful to the patient if the radioactive iodine had no effect.

The dosage was calculated in roentgens on the basis of the estimated weight of the gland and the calculated amount of radioactive iodine retained by it. The doses varied between 200 and 4,300 roentgens with most of the successes obtained with doses between 1,000 and 2,000 roentgens.

After the administration of the radioactive iodine, all patients were iodized in the usual manner with potassium iodide until the basal metabolic rate was normal. Results were de-

terminated by the behavior of the patient clinically after cessation of the routine iodine administration. If the basal metabolic rate remained normal or subnormal after the iodine was stopped, the patient was considered cured. If, on the other hand, the basal metabolic rate rose, or, if the patient's thyroid was removed surgically, the treatment was considered a failure. Some of the thyroidectomies had been planned, but for the purposes of the paper the patients were not considered cured by this method because of the lack of follow-up. All but two of the patients reported as cured have been followed for over two years.

Nine patients were classed as "failures." In one the dose was too small as judged by subsequent data. Another patient presented ophthalmic involvement which makes treatment with radioactive iodine difficult. Five patients had sufficient iodine to be effective and were later operated upon. Each patient developed postoperative myxedema or hypometabolism. It was concluded that the radioactive iodine had an effect on the thyroid tissue remaining after the operation.

In 24 cases there was a sufficient intensity of radioactive iodine for therapy and no subsequent operation. Only 3 of these were regarded after a long period of observation as not being cured. In most of the patients successfully treated the thyroid became normal in size. Three patients who had the largest pretreatment thyroids had persistently palpable, small glands, the consistency of which suggested chronic thyroiditis or fibrosis. None of the unoperated, successfully treated patients developed myxedema, or any other complication, such as anemia, tetany, loss of phonation, or laryngeal or tracheal irritation.—*E. F. Lang.*

HOFFMEYER, JØRGEN. The histologic picture of breast cancer after preoperative roentgen irradiation; a study of fifty cases. *Acta radiol.*, 1943, 24, 419-429.

The author describes the histopathologic appearance of breast cancer after preoperative roentgen treatment with fractionated doses of 1,000 to 4,800 r. In 40 cases the tumor diminished considerably in size—in 2 cases it disappeared entirely. Histopathologically a diminution of the cancer cell area was found but in no case was there complete disappearance of the cancer cells. In many instances these cells showed distinct degenerative changes. The

author's investigations confirm the observations of Reuterwall concerning the stimulating effect of the roentgen rays on the natural healing tendencies of breast cancer. It seemed that a total dose of 4,000 r was slightly more effective than a dose of 2,000 r. A warning is given against too long postponement of the surgical operation owing to the risk of fresh proliferation of the cancer cells.—*Mary Frances Vastine.*

HALBERSTAEDTER, L., and HOCHMAN, A. The artificial menopause and cancer of the breast. *J.A.M.A.*, July 6, 1946, 131, 810-816.

In recent years experimental studies on mice have established the importance of heredity, estrogens, and nursing in cancer of the breast in mice. In humans the estrogenic factor was suspected as early as 1889 when oophorectomy was suggested in treatment of breast cancer. Since then many workers have advocated sterilization, either by surgery or by irradiation. Several hundred cases have been reported. The most pronounced improvement has occurred in patients with metastases to the bones and to the skin. When there was irradiation of both metastases and ovaries, the improvement of the metastases was greater than could be expected from the local treatment alone. The work of Horsley was quoted. He did bilateral complete oophorectomies at the time of mastectomy in 25 cases in whom there were no metastases. There were only 2 in whom recurrences developed. In another group of 148 patients with no oophorectomy and no metastases at the time of operation, metastases developed in 51 per cent.

The authors report the histories of 60 women in whom artificial menopause was induced for cancer of the breast in various stages and of various types. Most of the cases were sterilized because of the presence of metastases. It was found that improvement occurred in 69 per cent of patients with bone metastases and in 50 per cent of those with pulmonary or pleural metastases. Response was less favorable in metastases to the skin or with local recurrence, and much less favorable with metastases to lymph nodes. Spread to the liver or brain did not respond at all. In 8 patients with no clinical evidence of metastasis, sterilization was done and at the time of publication, 6 were alive with no evidence of recurrence.

The results of induction of artificial menopause were much better in those patients in whom the malignancy was well differentiated,

and in whom the tumor was classified as a typical adenocarcinoma. Only 1 patient of the 11 with anaplastic tumors, designated carcinoma simplex, showed any improvement. The authors postulate a reason for this disparity. Typical adenocarcinoma tends to reproduce the morphology of a normal gland, and also its physiology. Thus, with artificial menopause, the tumor is deprived of an important growth factor. An anaplastic tumor does not resemble the gland morphologically nor functionally, and it does not respond so readily to either the presence or absence of the hormone.

Improvement following artificial menopause is only temporary, and only an exceptional patient is better for a longer period than two years. Probably the reason for this is the fact that ovarian sterilization does not entirely remove estrogenic hormones from the blood. The origin of the hormones in a castrated individual is not definite. In some mice hyperplasia of the adrenals occurs after castration. The pituitary and the thymus may also play a part in supplanting the ovaries. The authors feel that removal of the estrogen is the important factor in the improvement of these patients, and suggest irradiation of the adrenals, or administration of androgens, as additional possibilities for producing additional improvement.—*E. F. Lang.*

FORSSMAN, G. Über die Röntgendiagnostik und Strahlenbehandlung von Magensarkomen, insbesondere Lymphosarkomen und Reticulumzellensarkomen. (Roentgen diagnosis and radiation treatment of gastric sarcoma, especially lymphosarcoma and reticulum cell sarcoma.) *Acta radiol.*, 1943, 24, 343-373.

The author reports on the good therapeutic results secured in 9 cases of gastric sarcoma at Radiumhemmet, Stockholm. This tumor grows in the submucosa, the mucosa remaining intact for a long time. There is a bulging of the mucosa and peristalsis is early interfered with due to infiltration of the muscularis. The diagnosis of sarcoma is indicated by: (1) the smooth surface of the sarcoma, (2) its flexible edges, (3) the central crater, (4) the multiplicity of the lesions (at times), (5) the radiosensitivity of the tumor.

Preoperative roentgen treatment is desirable but is often hindered by diagnostic difficulties. Operable cases were treated by gastric resection and postoperative roentgen therapy with daily doses of 250, 300 or 400 r with a 0.5 mm. Cu or tin filter, 50-60 cm. focal distance and a total cutaneous dose of 2,500 to 3,000 r during four

to six weeks on each of two anterior and two posterior fields. In some cases supplementary series were given two to three months later.—*Mary Frances Vastine.*

MISCELLANEOUS

GARLAND, LEO H., and HARRIS, MILO T. Wet-film x-ray viewing room. *U. S. Naval Med. Bull.*, 1945, 44, 1288-1291.

To prevent interruption of darkroom work while viewing wet films some radiologists use an elongated wash-water tank which projects through the wall of the darkroom into an adjoining room. This was not possible in the authors' laboratory, so they created a small separate viewing room by shortening the maze, utilizing a dead space which happened to be present and shortening the control booth on the left side of the darkroom. A lightproof voice baffle was installed, consisting of two rectangular openings in the wall between the wet-film viewing room and the darkroom, each covered with a double thickness of black cheesecloth mounted on wooden frames. A pass tunnel was constructed below bench level large enough to carry a wooden frame holding six 14×17 inch films. This frame slides on two wooden rails and can be pushed into either room. The lightproof lids of the pass tunnel are guarded by a sliding metal bar on top, so that when one lid is opened the other cannot be raised. The room is 5 ft. 6 in. square and 7 ft. 6 in. high. It opens directly into the x-ray corridor by a wide doorway. No door was placed in this entrance, however, so as to give standing room for those wishing to examine the wet films.

Plans of the viewing room and adjoining spaces are given.—*Audrey G. Morgan.*

MAISSEN, LUIS. Die Thrombozyten unter Einwirkung von Radiumstrahlen im Dunkel-feldpräparat betrachter. (The effect of radium irradiation on thrombocytes observed in dark-field preparations.) *Radiol. clin.*, July, 1946, 15, 236-257.

The author studied the effect of radium irradiation on thrombocytes. He had six radium cells of 10 mg. each and exposed the thrombocytes to their action for from one to six hours. An hour's irradiation with six radium cells corresponds to about 2,000 radium units. Details of the preparation of the specimens and the irradiation are given.

He found that the radium irradiation has a

characteristic effect on the thrombocytes, the protoplasm of the cells being affected while the granular part is not. The effect differs from that of roentgen rays as shown by Willener. Under roentgen irradiation the number of active forms decreases and the number of resting forms increases but under radium irradiation both forms decrease markedly. The decrease runs parallel to the radium dosage. The transformation of active into resting cells is interfered with and two abnormal forms of active cells are produced—one with segmented pseudopodia and low protoplasm content which is called a small active form and one an indistinct form without sharp outlines and with no pseudopodia which is called a degenerating thrombocyte.

The fact that the injury increases directly with increase of radium dosage gives a method of somatic measurement of the action of radium irradiation on the human body and its cells.

The adhesion of the thrombocytes to the slide is also affected by the irradiation. The irradiated thrombocytes swim about longer in the field and become fixed thromboplastically to the slide later than cells that have not been irradiated. This is a further proof of injury of the protoplasm.—*Audrey G. Morgan.*

MULLIS, A., MINDER, W., LIECHTI, A., and WEGMÜLLER, F. Modellversuche zum biologischen Primäreffekt der Strahlenwirkung. II. Über die Wirkung der Röntgenstrahlen auf einige Halogenverbindungen des Benzols. (Model tests of the biological primary effect of irradiation. II. The effect of roentgen rays on some halogen compounds of benzol.) *Radiol. clin.*, Sept., 1946, 15, 295-312.

This series of experiments had two objects: (1) to study the irradiation hydrolysis of paradichlorobenzol in organic solvents which are themselves soluble in water, and (2) to study the irradiation hydrolysis of hexachlorobenzol in aqueous solution. Details of the results are shown in tables and graphs.

- In examining the first question, solutions of p-dichlorobenzene in ether of varying concentrations were made and these were dissolved in water and irradiated with roentgen rays. Radiation hydrolysis could not be definitely demonstrated in such solutions. Saturated aqueous solutions of p-dichlorobenzene on irradiation with roentgen rays yielded hydrochloric acid in amounts approximately proportional to the intensity of the irradiation. Roentgen irradiation dissociates p-dichlorobenzene with the production of hydrochloric acid only in the presence of water. This reaction is without doubt a radiation hydrolysis.

Radiation hydrolysis does not occur when a saturated aqueous solution of hexachlorobenzene is irradiated.

The reason radiation hydrolysis of p-dichlorobenzene does not occur in the presence of ether is apparently that the ether transforms the radiant energy into some form that does not produce this reaction.

The failure of radiation hydrolysis to occur with hexachlorobenzene is probably due to the absence of hydrogen atoms, which shows that both hydrogen and chlorine atoms are directly involved in the radiation hydrolysis of polychlorobenzenes. Further work is necessary to explain the mechanism of the reaction.—*Audrey G. Morgan.*



THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 59

FEBRUARY, 1948

No. 2

SUPERFICIAL SPREADING CARCINOMA OF THE STOMACH

By ROSS GOLDEN, M.D., and ARTHUR PURDY STOUT, M.D.

NEW YORK, NEW YORK

CARCINOMA of the stomach is an epithelial growth which arises in the mucous membrane except in very rare instances where it may arise from ectopic epithelial cells in the deeper layers of the gastric wall.

To be detected by roentgen examination, a growth must produce alterations in the form or the movement of the stomach wall which can be recognized by this method of observation. If a cancer could grow without changing the gastric outline or movements, it obviously could not be detected. This has actually happened in some cancers of the fundus, where movements are rarely demonstrable.

After an abnormality has been detected, it must be differentiated from abnormalities produced by other conditions, particularly benign peptic ulcer and the inflammatory process ordinarily called gastritis.

The demonstrability of a carcinoma depends upon two factors: (1) the location in the stomach, and (2) the gross growth characteristics of the neoplasm.

In a group of 205 proved carcinomas seen at the Presbyterian Hospital, 75 per cent originated in the antrum, 20 per cent in the media and 5 per cent in the fundus. Fortu-

nately, the great majority of carcinomas develop in the lower part of the stomach, which is accessible to the palpating hand, and where spontaneous movements occur normally. The importance of the location of the growth in the stomach is great but cannot be discussed further here.

The microscopic character of the cells composing a carcinoma of the stomach is of little or no significance as far as the problem of detection is concerned. On the other hand, the way the growth develops *grossly* is of great importance.

CLASSIFICATION

Malignant tumors have two basic growth characteristics, (1) the mass-producing quality, and (2) the invading or infiltrating quality. In some tumors one of these two qualities may predominate, almost to the exclusion of the other. Upon these physical growth characteristics Stout has based a classification of carcinomas of the stomach.

- I. Fungating: grows into the lumen and produces a mass. It invades the deeper layers slowly and metastasizes late. It was found in 25 per cent of 200 cases.

* From the Departments of Radiology and Surgical Pathology, College of Physicians and Surgeons, Columbia University, and the Radiological Service of the Presbyterian Hospital, New York. Presented before the Forty-eight Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 16-19, 1947.



FIG. 1. Ulcerating Superficial Spreading Carcinoma of the Lesser Curvature and a Separate Superficial Spreading Carcinoma of the Anterior Wall of the Antrum.

A fifty-two year-old man (Unit No. 640776) had pain beneath the lower end of the sternum for ten weeks, at first relieved by milk. Roentgen examination May 7, 1941 (A) disclosed a crater shadow in the region of the incisura angularis with a small six-hour gastric residue. Another examination June 10, 1941 showed the crater to be less angular and possibly slightly smaller. At gastroscopy May 21, 1941 the ulcer was seen but nothing consistent with carcinoma was detected. The second gastroscopy June 18, 1947 disclosed nodular swelling of the margin of the crater but the gastroscopist was not sure whether this was due to edema or malignant disease. At this time the patient was free from pain. At the third roentgen examination June 25, 1941 the crater shadow appeared to be about one-third its original size. During this examination the persistently sluggish stomach suddenly developed four peristaltic waves which were recorded with the spot film device (B). The site of the crater is indicated by the arrow. This gives the impression that the wall is perfectly flexible practically to the margin of the crater, and led one of us (R. G.) to believe that a diagnosis of carcinoma was not justified. However, all of these peristaltic impressions are unusual, if not abnormal, in that the greater curvature indentations are deeper than those on the lesser curvature and the

II. Spreading: grows along the wall and produces no mass.

A. Superficial: spreads in the mucosa and submucosa. It was found in 14 per cent of 200 cases.

1. Ulcerating—about 80 per cent.

2. Non-ulcerating—about 20 per cent.

B. Linitis Plastica type: spreads in the submucosa, muscle coat and subserosa. It was found in only 2.5 per cent of 200 cases.

III. Penetrating: grows through the wall to the serosa, and destroys and replaces the muscle. It was found in 26 per cent of 200 cases. It always ulcerates.

IV. Unclassifiable advanced growths found in 32.5 per cent of 200 cases.

This discussion is concerned with the superficial spreading type and the differential diagnostic problems connected with it.

PATHOLOGY

Superficial spreading carcinoma begins in and grows along the mucosa. The malignant growth replaces the mucous membrane, usually obliterates the mucosal folds and smooths out the surface. In the surrounding area the mucosal folds radiate toward the cancer, whether or not ulceration has occurred, and reach the edge of the involved area. In some places the tumor cells extend

into the folds for a short distance and widen them. The malignant disease usually penetrates through the muscularis mucosae into the submucosa. In a few cases it is limited to the mucous membrane alone. In the most advanced cases, malignant cells penetrate between the muscle bundles of the tunica muscularis and may reach the serosa, but the muscle is not destroyed or replaced by the malignant tissue. This is in contrast to the penetrating type which does destroy and replace muscle.

Carcinoma of the stomach of any type is invariably associated with pathologic evidence of gastritis. In some cases this inflammatory process is far advanced.

MATERIAL

Superficial spreading carcinoma of the stomach was first recognized in the Department of Surgical Pathology of the Presbyterian Hospital in 1937. Between 1937 and 1947, 31 of them have been discovered.

The average length of time in 29 cases between the onset of symptoms referable to the stomach and the hospital admission during which operation was performed was nearly two years; the longest was ten years and the shortest was one month. In one case this figure could not be determined and in another the patient had not complained of digestive symptoms at the time of the examination. The latter was included in the

latter are quite wide with sloping margins. At the third gastroscopy July 2, 1941 the margins of the crater were elevated and nodular, the ulcer seemed to be healing poorly and the gastroscopist interpreted this as evidence of cancer. A pressure film (C) taken at the fourth roentgen examination (July 3, 1941) shows that the crater is smaller in depth but it is just as wide as ever at the level of the mucous membrane. This is in contrast to the way the ulcer healed in Figure 2. On the resected specimen (D) an ulcerating superficial spreading cancer 2.7 cm. in diameter was present on the posterior wall side of the lesser curvature about 5.5 cm. from the pylorus. A second and entirely separate superficial spreading carcinoma measuring about 1 cm. in diameter (approximately outlined by arrows) was present on the anterior wall very close to the pylorus which did not extend into the submucosa. On the proximal and posterior wall side of the ulcer, the mucosal folds come near the crater but do not enter it. On the inferior and anterior wall side they are interrupted at some distance from the crater. At the margins of the smaller cancer the mucosal folds are obliterated. Although the larger cancer measured on the specimen 2.7 cm. in diameter, in the living stomach it may well have had a greater diameter. Almost certainly the cancerous area was pulled inward by the contractions adjacent to the ulcer shown on (B). The question arises as to whether the abnormal width of the indentation on the lesser curvature and the greater depth of the indentation on the greater curvature can be taken as evidence of stiffening of the mucous membrane and submucosa by malignant cells, and as to the possibility that submucosal edema and inflammatory infiltration can produce a similar disorder of peristalsis.

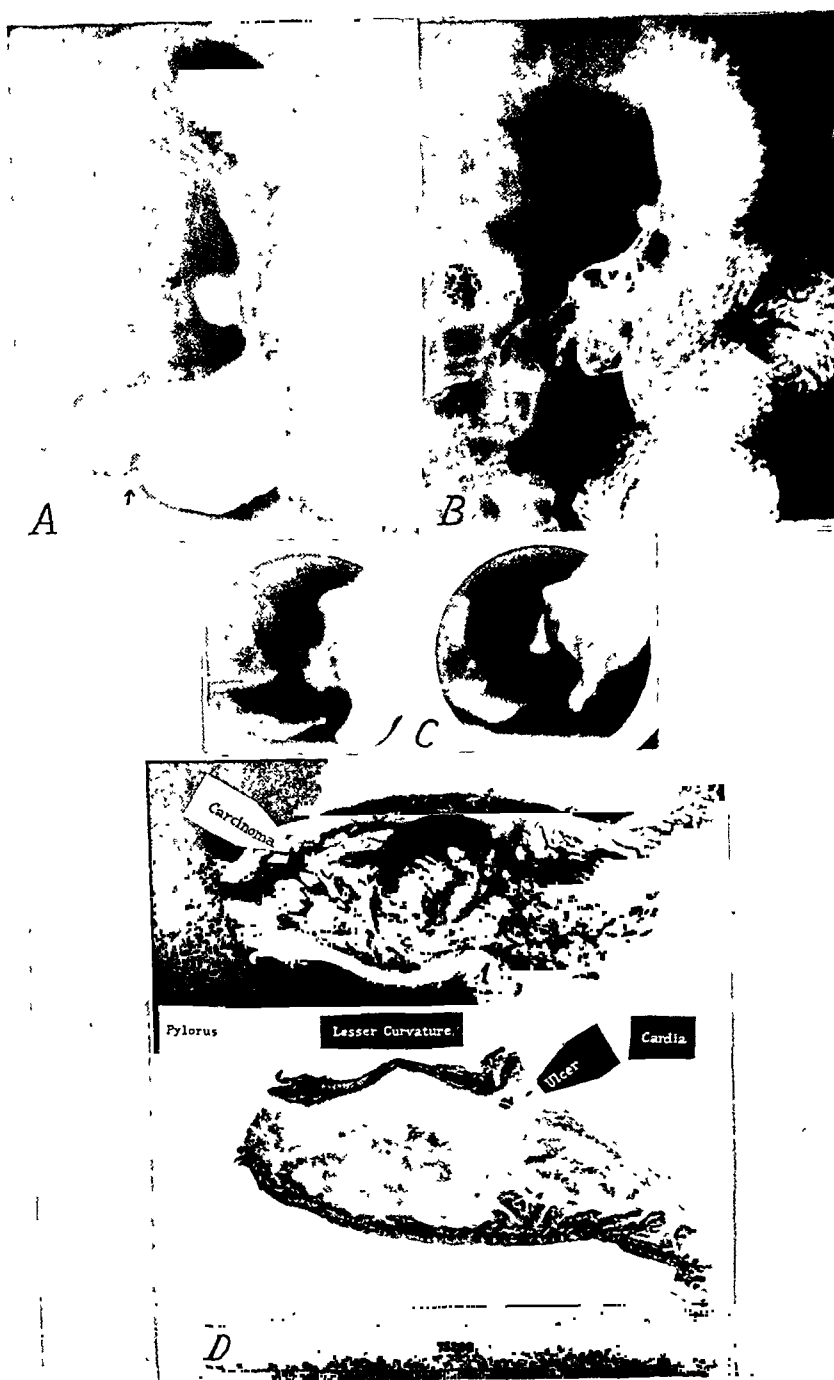


FIG. 2. Superficial Spreading Carcinoma of the Antrum with a Separate Healing Peptic Ulcer of the Lesser Curvature.

A fifty-two year old man (Unit No. 595656) complained of epigastric pain of two months' duration, accompanied frequently by vomiting. During this period he lost 17 pounds. Gastric analysis disclosed free HCl 65. Roentgen examination on December 14, 1939 (A) showed a large crater on the lesser curvature with undermined margins, an incisura on the greater curvature of the antrum thought to be due to reflex spasm, and a trace of six hour gastric residue. Gastroscopy December 29, 1939 disclosed a shallow ulcer on the anterior wall of the antrum, irregular in outline with slightly raised edges. Peristaltic waves faded out in the region of this ulcer. This was interpreted as ulcerating carcinoma. The patient refused operation. The second roentgen examination on January 4, 1940 (B) showed the crater on the lesser curvature to be smaller in depth and narrower at the level of the mucosa, which is characteristic of a healing peptic ulcer. The in-

series of 2,432 symptomless gastric survey cases reported by St. John, Swenson and Harvey.¹

Of the 31 cases, 21 (67 per cent) were men, and 10 (33 per cent) were women. The age distribution was: under 40 years, 2; 41 to 50 years, 6; 51 to 60 years, 15; 61 to 70 years, 6; 71 to 80 years, 2. The oldest patient was 80 and the youngest 34 years.

One stomach contained two superficial spreading cancers (Fig. 1); the smaller was located on the anterior wall of the antrum and was about 1.0 cm. in diameter. This was the smallest in the series of 31 cases. The largest occupied an area of approximately 180 sq. cm.

In 2 cases, mixed types of carcinoma were present. One had a fungating growth, which had not penetrated through the muscularis mucosae, associated with a superficial spreading cancer which had penetrated into the submucosa at only one point. Another stomach showed superficial spreading cancer around a penetrating cancer. In 2 of the resected stomachs multiple foci of superficial spreading cancer were found with uninvolved mucous membrane between them.

Metastases to regional lymph nodes were present in only 15 of the 31 cases.

The superficial cancer developed in the lower half of the stomach in 30 of the 31 cases. In 1 case it occurred around the cardiac orifice and involved the fundus.

Peptic ulcer, as distinguished from superficial erosions of the mucosa, is defined pathologically as an excavation in the

stomach wall which penetrates into and often through the muscle coat, sometimes into the gastrohepatic omentum. The destroyed muscle cannot be reproduced and the excavation, as it heals, must be filled in by scar tissue. The demonstration of localized scar tissue in the stomach wall establishes the fact that peptic ulcer is or has been present.

Cancer developed around an open peptic ulcer in 12 cases, in 3 of which secondary ulceration in the cancer occurred.

In 2 cases cancer developed in the mucous membrane over the scar of a healed peptic ulcer (Fig. 5).

The carcinoma itself ulcerated in 14 cases, in addition to the 3 ulcerating cancers associated with open peptic ulcers, mentioned above.

In 4 cases superficial spreading cancer was present without ulcer.

An open ulcer was present, therefore, in 26 (approximately 80 per cent) of 31 cases. One had a healed peptic ulcer with an ulcerating cancer in a different area. Another patient had ulcerating carcinoma of the anterior wall of the antrum which increased in size and a separate peptic ulcer high on the lesser curvature which diminished in size under observation (Fig. 2).

GASTROSCOPY

Gastroscopy was done in 11 cases. This procedure was carried out three times in 3 cases, twice in 2 cases, and once in 6 cases. In 9 of these 11 cases, the gastroscopist sooner or later found evidence interpreted as consistent with or suggestive of cancer. In 2 instances, he saw no evidence of carcinoma. The gastroscopist saw nothing to

¹ St. John, F. B., Swenson, P. C., and Harvey, H. D. An experiment in the early diagnosis of gastric carcinoma. *Ann Surg.*, 1944, 119, 225-231.

cisura in the antrum was reproduced. Pressure films of the antrum made four days later (C) showed an irregular barium shadow corresponding to the level of the anterior wall ulcer described by the gastroscopist. The second gastroscopy January 24, 1940 showed that the anterior wall ulcer had increased in size, and had a yellowish nodular base. The third roentgen examination January 25, 1940 disclosed marked spasm of the antrum, and still further decrease in the size of the lesser curvature ulcer. Partial gastrectomy was then done. The specimen (D, photographed after fixing) showed an ulcer on the anterior wall about 2.0 cm. in diameter and 0.1 cm. deep. Microscopic sections disclosed carcinoma limited to the mucosa and submucosa. One of 14 regional lymph nodes contained metastases. High on the lesser curvature was a healing benign peptic ulcer, which on the photograph appears as a hole in the stomach wall.

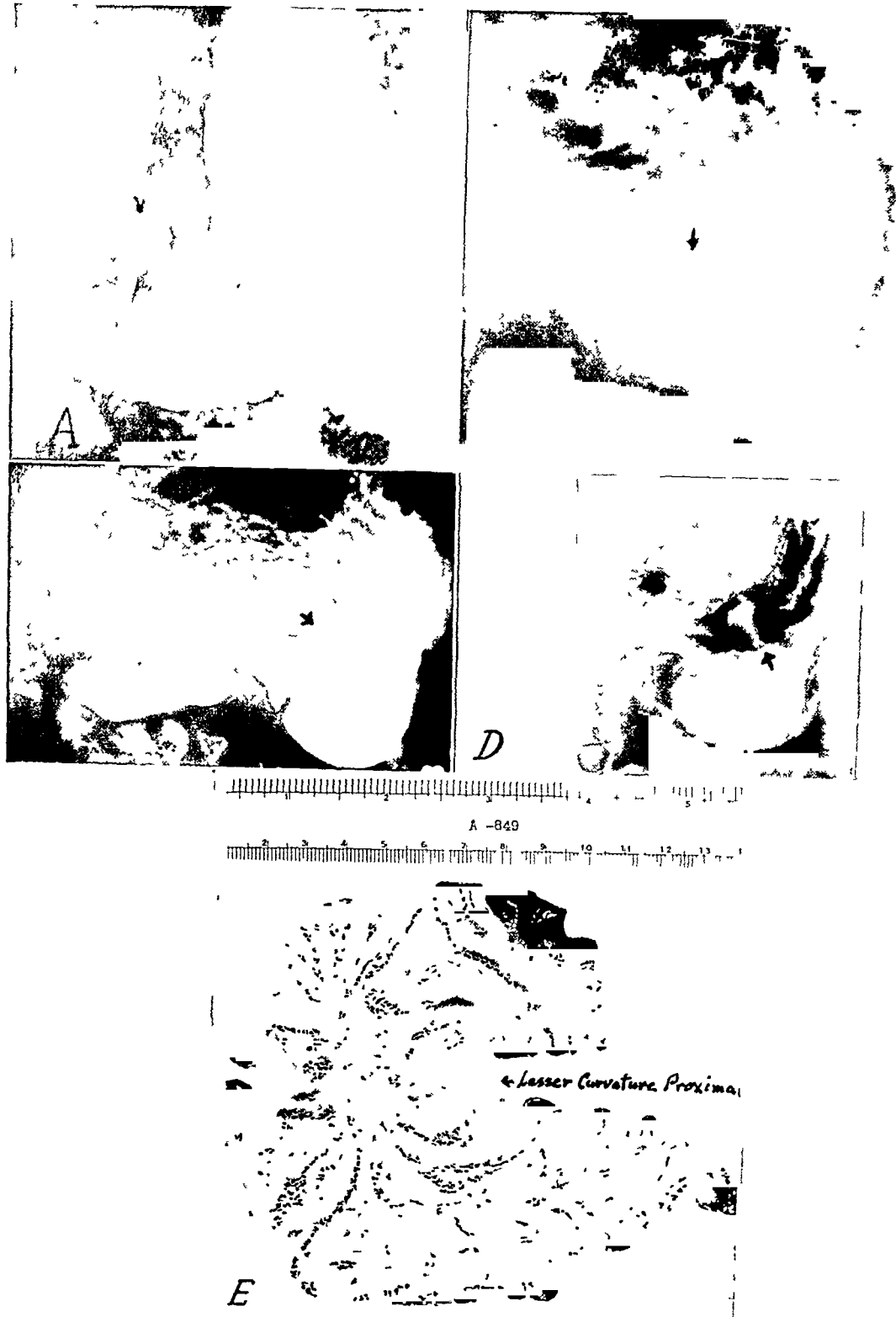


FIG. 3. Superficial Spreading Carcinoma Developing in the Margin of a Peptic Ulcer.
A fifty-three year old man (Unit No. 851031) was admitted December 4, 1946 because of epigastric pain which began four years previously. Roentgen examination in 1943 was said to have shown no ulcer. He was fairly comfortable on a strict diet for the next two years. The pain recurred and a roentgen examination

suggest cancer at the first observation in 4 cases, but on the second examination in 1 case and on the third examination in 3 cases, evidence of cancer was described. There is little doubt that cancer actually developed during the period of observation in at least 2 instances. In one of these approximately eleven months (Fig. 4), and in the other approximately five months elapsed between the gastroscopic examination at which no evidence of cancer was seen and the one at which evidence of cancer was detected. The involved area was visible at both examinations.

ROENTGEN EXAMINATION

An analysis of the records gives the following information about the results of roentgen examination of these stomachs. Two patients had examinations before admission, no details of which are available; on pathologic examination both of them had ulcerating cancers. Twenty-nine of the 31 patients had roentgen examinations at the Presbyterian Hospital, of which 24, on pathologic examination, had either ulcerating cancer or peptic ulcer with cancer. In 20 of these the ulcer was demonstrated by roentgen examination. The ulcer in the cancer was small and very superficial in a few, which is presumably the reason it was not demonstrated in the 4 cases. Certainly the presence of an ulcer helps in the detection of disease, particularly in the early cases.

The roentgen examination in 1 case disclosed what appeared to be a shallow ulcer on the lesser curvature. This crater shadow was smaller after three weeks of treatment. A diagnosis of carcinoma was made because of obliteration of mucosal folds around the crater shadow, with apparent loss of flexibility of walls. The pathologist found a shallow depression in the wall at the site of the growth but, because of the absence of necrosis, could not call the depression an ulcer.

Elongated spasm of the antrum, resembling the antral narrowing associated with antral gastritis (Fig. 4), was found in 9 of the 29 cases; a localized incisura at the level of the diseased area was present in 3 (Fig. 2).

A six hour observation was recorded in 26 of the 29 cases examined at the Presbyterian Hospital. A six hour barium residue was present in the stomach in 21 cases, of which 2 had twenty-four hour residues (Fig. 5). In 3 cases the stomach was empty at six hours. A six hour observation was apparently not made in 5 cases. It appears that delay in emptying the stomach occurred in some degree in approximately three-quarters of the cases, but is of no significance in the differential diagnosis.

The elapsed time between the first roentgen examination and the operation in the first 7 cases which were seen in 1937-1938 inclusive averaged 115 days; the longest was 191 days and the shortest

elsewhere on May 29, 1945 disclosed a penetrating ulcer of the lesser curvature of the antrum with undermined margins (*A*). On a dietary regimen he had no symptoms for over a year when they recurred. A roentgen examination elsewhere in November, 1946 disclosed a crater shadow on the lesser curvature of the antrum (*B*) which is not as deep as the crater shown in 1945. Another roentgen examination at the Presbyterian Hospital December 26, 1946 disclosed a peculiar double crater on the lesser curvature (*C*). A spot film without pressure taken with the patient supine (*D*) shows the crater *en face*. The crater has a peculiar trilobed appearance. The mucosal folds do not run into the crater on the lesser curvature and the pyloric side. At operation the surgeon found evidence of an ulcer with nothing he could consider suggestive of a carcinoma. The resected specimen (*E*) showed an ulcer on the lesser curvature which seemed to be made up of three confluent craters, the largest of which had a punched out appearance with overhanging edges on the proximal side. The three confluent craters occupied an area of about 3 cm. along their widest diameter. The two smaller craters were shallow and upon microscopic examination were found to be ulcers in superficial spreading carcinoma which arose on the lesser curvature and pyloric side of the peptic ulcer. The arrow points to the largest ulcerated area in the cancer. The secondary ulceration in the cancer explains why the crater, as seen *en face*, had a trilobed appearance. This patient undoubtedly had at least one peptic ulcer which healed. The recurrence in 1946 developed cancer on part of its margin before it had time to heal.



FIG. 4. Superficial Spreading Carcinoma of the Lesser Curvature with Involvement of the Mucosa Alone and Associated with Antral Spasm.

A fifty year old man (Unit No. 522052) complained of gas after meals for four years and of stabbing epigastric pain relieved by milk for one year. Roentgen examination June 28, 1937 (A) disclosed spasm of the prepyloric region interpreted as antral gastritis. Gastroscopy July 14, 1937 disclosed erosions on the anterior wall of the stomach in the antral region, each about 6 to 7 mm. in diameter. The second gastroscopy, December 1, 1937, showed atrophic mucosa where the erosions had previously been seen. The second roentgen examination October 4, 1938 (B) showed a striking increase in the degree and in the length of the spasm of the antrum. The third gastroscopy November 7, 1938, approximately eleven months after the second, disclosed small nodules on the mucous membrane along the lesser curvature and anterior wall of the antrum, interpreted as diffuse carcinoma. No peristaltic movement was seen in this area. The cancer developed where the erosions were seen at the first gastroscopy and the atrophic mucous membrane at the second. The third roentgen examination on November 14, 1938 (C) showed spasm of the antrum with small irregularities on the lesser curvature above the narrow region. On the greater curvature opposite these irregularities is a peristaltic indentation with no corresponding indentation on the lesser curvature. Just proximal to the irregular area on the lesser curvature is a peristaltic wave with indentations on both curva-

thirteen days. The patient who was operated on thirteen days after the first roentgen examination was the last one of the 7 seen in 1937-1938. The average time for the first 6 cases in this group was considerably longer than 115 days.

The average elapsed time between the first roentgen examination and the operation in 13 cases seen between 1939 and 1942 inclusive was twenty-six days; the longest was fifty-three days and the shortest was three days.

The average elapsed time between the first roentgen examination and the operation in 9 cases seen in 1943 to 1947 inclusive was thirty-eight days; the longest was 142 days and the shortest was five days. The patient with the longest time in this group was a woman, aged seventy, with hypertension and other complications. In spite of a positive diagnosis of cancer of the stomach by roentgen examination on admission and a similar diagnosis made by gastroscopy about three months after admission, the surgeons hesitated to operate upon her. Her complicating conditions made operation more than usually hazardous. Although she had postoperative lobular pneumonia, the fatal outcome was apparently precipitated nine days after the operation by a severe reaction following the intravenous administration of an amino acid preparation. However, the delay between the diagnosis by roentgen examination and the operation is now recognized as a mistake. Without this one case the average time between the first roentgen

examination and operation in this last group would have been about the same as that of the second group.

Two patients were examined elsewhere and the dates are not recorded.

The roentgen examinations in these cases were done by a number of individuals who varied greatly in experience. Some of them were residents in training. However, the interpretation of the roentgen examination was at times very difficult even for the most experienced observers. The analysis of the elapsed time given above shows, nevertheless, evidence of improvement in the ability of the observers of these cases, both radiological and clinical, to reach a decision to operate.

PROBLEMS IN DIAGNOSIS

In retrospect, the difficulty in the diagnosis of superficial spreading carcinoma of the stomach lies mainly in three problems. The first problem is the detection of cancer developing around an open peptic ulcer. The second problem is the detection of cancer developing in association with spasm of the antrum. In a few cases these two problems were combined. The third problem is the possible effect of cancer growing in the mucosa alone or in the mucosa and submucosa on peristaltic movements and the flexibility of the wall.

1. Can cancer developing around the margins of an open peptic ulcer be detected?

If secondary ulceration in the cancer occurs, it may produce apparent lobulation

tures. The resected specimen (*D*; unfortunately not photographed until after fixing) disclosed an irregular lesion about 6×9 cm. on the lesser curvature and extending onto both anterior and posterior walls, approximately outlined by arrows. In its center were small nodules 3-5 mm. in diameter with slightly depressed areas of ulceration. The involved area of mucosa was immovable over the muscle. Microscopic examination showed carcinoma involving only the mucosa, associated with chronic gastritis. No evidence of metastases was present in the regional lymph nodes. It seems reasonably certain that carcinoma developed in the atrophic mucosa some time in the eleven months between the second and the third gastroscopy. The significant roentgen manifestations were (1) an increase in the spasm of the antrum, (2) the small irregularities on the lesser curvature, and (3) the obliteration of peristalsis along the involved area of the lesser curvature. Although the cancer involved only the mucosa, the mucous membrane was immovable over the muscle coat. This fixation of mucosa to muscle cannot be attributed to the cancer which had not extended into the submucosa. Presumably, therefore, it must be the result of an inflammatory reaction in the submucosa associated with gastritis. It is uncertain whether the obliteration of peristalsis on the lesser curvature was due to the carcinoma in the mucous membrane or to the submucosal inflammatory reaction, or to a combination of the two.

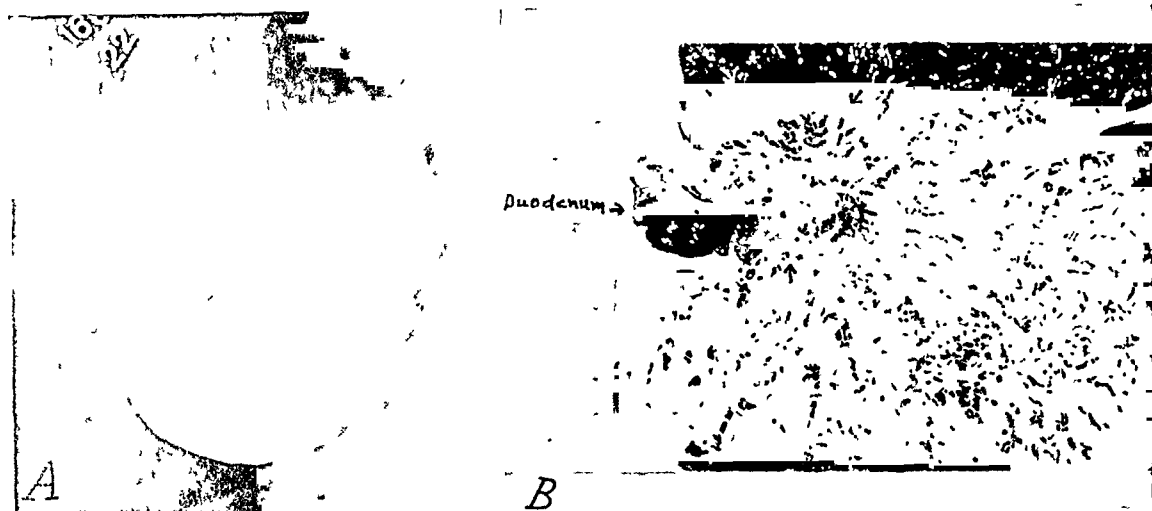


FIG. 5. Superficial Spreading Carcinoma Arising over the Scar of a Healed Peptic Ulcer, Associated with Prepyloric Spasm.

A fifty-six year old man (Unit No. 650712) had epigastric fullness and vomiting about a quarter of an hour after eating for two years, increasing in severity. He had no pain. He lost 23 pounds in six months. Roentgen examination on August 26, 1941 showed that no barium left the stomach in six hours, and that a large twenty-four hour gastric residue was present. The cause of the retention, aside from spasm, could not be determined. He was given dietary treatment with daily gastric lavages. The second roentgen examination September 5, 1941 showed no evidence of improvement in the emptying of the stomach. At operation on September 11 a puckered scar was found on the lesser curvature in the prepyloric area. A posterior gastroenterostomy was done. The third roentgen examination September 22, 1941 (A) disclosed evidence of a complete pyloric obstruction. Very little barium passed through the gastroenterostomy. At the second operation, September 25, 1941, edema of the stoma was found. Partial gastric resection was done. The specimen (B) showed organic stenosis of the pylorus which was so narrow that a probe was passed with difficulty. The pyloric muscle was hypertrophied. In the prepyloric region the mucosa was thin and was fixed to the muscle coat. The 1.5 cm. scar of a healed ulcer was present on the anterior wall side of the lesser curvature about 3 mm. from the pylorus. On microscopic examination a carcinoma 6 cm. in diameter was found in the mucosa over the scar, which had penetrated slightly into the cicatrix at one point. The approximate area is outlined by arrows. The mucosa was not thickened and the cancer was not recognized by the pathologist on inspection and palpation of the fresh specimen. The patient died at home five and a half years later with a mass in the right upper quadrant presumably from metastases.

of the margin of the crater shadow. To demonstrate this, films of the crater filled with barium should be made in some way so that the form of the crater's rim can be seen *en face* as well as in profile (Fig. 3). In peptic ulcer, the mucosal folds run into the crater. If cancer develops around the ulcer, the mucosal folds stop at the edge of the cancer. The failure of peristaltic indentations to run up close to the crater is suggestive but not conclusive evidence of cancer. This may be difficult to demonstrate with certainty, because of the disorder of peristalsis so frequently associated with gastritis and antral spasm. Under treatment, the healing crater of the peptic ulcer should diminish in size in all directions,

in transverse diameter across the mucosal margin as well as in depth; whereas the cancerous crater may diminish in depth but diminishes little or not at all in transverse diameter (compare Figures 1 and 2).

2. Does cancer in the mucous membrane and submucosa cause spasm of the muscle coat, or is the spasm the result of an inflammatory process in the stomach wall?

A study of our cases suggests that cancer under these conditions can cause spasm of the muscle, but it usually is no different from the spasm often associated with inflammatory disease of the wall. Unfortunately, edema and other inflammatory changes are often present with carcinoma. If the spasm increases either in degree or in

length while the patient is under observation, carcinoma should be suspected. A localized incisura on the greater curvature, which may vary in width from time to time, has been present in some cases, and should serve to direct critical attention to the wall at that level.

3. Does cancer in the mucous membrane and submucosa modify peristaltic movements and stiffen the wall in such a way that it can be differentiated from the effect of inflammation?

Almost certainly this differentiation cannot be made in all cases at the present time. Probably the effect would depend upon the degree of inflammation and of submucosal edema. Carcinoma infiltrating the mucous membrane has definitely obliterated peristalsis over the infiltrated area in some cases (Fig. 4) and apparently not in others. The wave may be shallow in the infiltrated area and normally deep opposite it (Fig. 1). It seems possible that the degree of interference with the movement of the gastric wall depends upon the size of the area involved by the carcinoma. One difficulty is to be sure of the accuracy of the observation. It seems advisable to assume that carcinoma is probably present if dampening or obliteration of the peristaltic impression occurs over a localized area, particularly if small irregularities of the margin or other suggestive signs are present.

SUMMARY AND CONCLUSIONS

Superficial spreading carcinoma of the stomach grows along the mucosa or in the mucosa and submucosa. Its physical effects on the stomach wall are: (1) replacement of the mucosa; (2) radiation of the mucosal folds toward the growth; (3) obliteration of the folds by the growth; (4) widening and stiffening of the folds immediately around the growth; (5) nodule formation on the surface; (6) ulceration. This type of cancer does not produce a mass.

A study of 31 cases has shown that the difficulty in the great majority was not to

detect an abnormality on roentgen examination of the stomach but was rather to make sure that cancer was or was not present in an obviously abnormal stomach. Cancer may develop at any time in a patient who has suffered for years from peptic ulcer or gastritis. To detect these cancers, the examination must be elaborate and painstaking, with fluoroscopy and films in various positions. Roentgen cinematography would be very helpful, if it could be switched on at the time a rare peristaltic movement occurs in a persistently sluggish stomach. We must look for and try to understand details of structure and movement of the stomach wall to which we have paid too little attention, e.g., the character and shape of the margins of the stomach shadow, the shape of the ulcer crater, the relation of the mucosal folds to the crater. The crater, if possible, should be seen *en face* as well as in profile. Lobulation of the margins of the crater, a persistent incisura in the antrum even in the absence of a demonstrable ulcer, an increase in the length and degree of spasm of the antrum, and a diminution in the depth but not in the transverse diameter of the mucosal margin of a crater are signs suggesting cancer.

This study has emphasized to us the difficulty of determining accurately what area on the resected specimen corresponds to a given point on the shadow of the living stomach, unless a gross lesion such as an ulcer is present. Even then it is difficult to estimate on the film the extent of the involved area as shown on the specimen. With resection, the stomach muscle contracts but how much it contracts is not known. Nevertheless we must determine the exact extent and character of the disease in the wall of the resected specimen and correlate it as best we can with the roentgenologic examination. In no other way can knowledge concerning small early cancers of the stomach be increased.

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PENETRATING WOUNDS OF THE ABDOMEN

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INTRODUCTION

IT IS of prime importance to determine whether a penetrating missile has or has not entered the peritoneal cavity. Often, physical signs and symptoms are sufficient to warrant a laparotomy. However, more often than it is generally believed, the signs and symptoms are misleading. Thus, nearly all penetrating wounds of the retroperitoneal space and of the abdominal wall itself produce signs and symptoms which are, for practical purposes, indistinguishable from those accompanying intraperitoneal injuries. Penetrating wounds of the lower chest are also capable of producing pain and rigidity of the abdomen as well as the shock picture. Conversely, many cases of definite intraperitoneal injuries have been encountered with few or no signs and symptoms. This has happened a sufficient number of times to make the initiated and the experienced surgeon rely greatly on any roentgen finding which indicates with certainty that a missile has entered the peritoneal cavity.

These general statements have been attested to by many authors. Reinberg,⁶ in a review of roentgen diagnosis in gunshot wounds in U.S.S.R., states that in many cases of peritoneal entrance symptoms were so few that surgeons would not consider laparotomy until roentgen diagnosis urged it. Lenk,² in a review of the role of the roentgen ray in World War I, states the same.

This study is based on over 600 abdominal roentgen examinations made in World War II in an evacuation hospital close to the front lines, in which the examination was made within hours of the time of the injury. Particular stress will be laid on a new aspect of the technique of such an examination.

THEORETICAL CONSIDERATIONS

When a missile enters and leaves the

abdomen, an anteroposterior and a lateral view are obviously of no value to determine whether the missile has or has not entered the peritoneal cavity. When a missile enters and does not leave the abdomen, it is presumed that an anteroposterior and a lateral view will aid in solving this perplexing and important problem. Experience in many cases, however, shows that this examination is of little value and often misleading for a number of reasons. The final resting place of a missile gives no indication of its course through the abdomen. Thus, we have seen cases in which a missile enters the anterior abdominal wall from the side and lodges in the anterior abdominal wall in the midline, and in its course enters the peritoneal cavity. On the other hand, we have seen a bullet enter the left posterior abdominal wall, course through the abdominal wall on the left side, and lodge in the anterior abdominal wall in the midline without traversing the peritoneal cavity. In these cases, an anteroposterior and lateral view can be definitely misleading. Thus, in the first instance, the point of entrance of the missile, and the anteroposterior and lateral views might lead to the conclusion that the peritoneum was not entered, and in the second instance, lead to the conclusion that the peritoneum was entered. An anteroposterior and lateral view can also be misleading because, when the missile is far from the film, the slightest shift of the patient away from the perpendicular in the lateral exposure can make a great error in the determination of the final position of the missile on the roentgenogram. In severely injured patients it is often impossible, because of associated injuries, to position the patient in a perfect lateral. Then, too, we have seen cases in which a missile lodged in a large retroperitoneal hemorrhage and protruded so far into the abdomen that on the anteroposterior and lateral views the location of the

missile appeared to be in the exact center of the abdominal cavity.

The most reliable roentgenological index of the course of a penetrating wound is a demonstration of a pneumoperitoneum. Roentgen visualization of spontaneous pneumoperitoneum and its diagnostic significance has received a great deal of attention in medical literature. M. Weinberger,¹² in 1908, and Popper⁵ in 1915, were among the first to report on subphrenic air. Nearly all the reports deal with subphrenic air and its significance in the diagnosis of ruptured peptic ulcer. Thus, Vaughan and Brams⁹ showed the presence of air in 86.7 per cent of 65 cases of ruptured peptic ulcer; Vaughan and Singer¹⁰ showed it in 85.7 per cent of 63 cases; Odom and DeBailey³ in 64.6 per cent of 164 cases. DeBailey,¹ in a review of the literature of 1,267 cases, states that this finding is present in 69.4 per cent. Pearce⁴ believes that the figure is closer to 50 per cent. Although it has been known for some time that the appearance of a pneumoperitoneum is of diagnostic significance after a traumatic wound of the abdomen, only a few reports of a series of such cases have appeared in the literature. Reinberg⁶ writes of the importance of this examination to the military surgeon of U.S.S.R. in World War II. Lenk² in 1916 reported on this finding after his experience in World War I.

Authors who have written about the demonstration of pneumoperitoneum state that the patient should preferably be examined in the sitting position so that the air may rise to the diaphragm and above the liver and stomach. If this position is impossible, then it is advised that the patient be placed on his left side and a postero-anterior or anteroposterior exposure made with a horizontal beam of roentgen rays. This demonstrates free air under the right diaphragm. If this position is impossible, then it is suggested that the patient be examined in the recumbent position with a horizontal beam of roentgen rays. This order of preference is generally accepted, and few authors bother to speak of the recumbent position at all. It is the purpose

of this paper to show that the recumbent position is the preferable one in the demonstration of free air in the peritoneal cavity.

THESIS

With the above information as a guide, we examined our abdominal injury cases in the conventional sitting, or left lateral positions. However, so many war casualties have multiple injuries that it is difficult, wrong, and in many cases impossible to position the patient. As a result, we were forced to examine the patient in the position that the patient came to us—usually in the supine position. A 14 by 17 inch cassette was held erect by a litter-bearer on either side of the patient, and a lateral exposure made with the central ray directed horizontally about 2 inches posterior to the anterior abdominal wall. After we learned to detect free air in the peritoneal cavity in this view, we were greatly surprised to find that our correlation with the clinical and surgical findings was much higher than in those cases where the more usual sitting and left lateral positions were taken. A possible explanation presented itself and was later proved in at least 10 cases. When a patient with an intraperitoneal injury arrived in the roentgen-ray tent in the supine position, the free air presumably rose to the top and was concentrated in the peritoneal cavity in close apposition to the anterior abdominal wall. When the patient's position was changed for the few seconds of a roentgen examination, it was presumed that not enough time elapsed for a small amount of air to collect in the new position to be visible on the roentgenogram. Thus, Thaxter,⁸ in showing that no harm is done to the patient in placing him in a sitting position, states that this position should be held for only fifteen seconds. Figure 1 is the roentgenogram of a soldier whose original film taken in the sitting position failed to show air. Because this patient was so definitely positive clinically, and because of the above theoretical considerations, we roentgenographed him again after an interval of thirty minutes, in the supine position, with this gratifying result (Fig.



FIG. 1. The original sitting film of this patient showed no free air. Repeat examination in the supine position shows free air. Note that the free air follows the curve of the diaphragm, is sharply demarcated anteriorly and posteriorly, and is limited above and below by tapering points. Note on the same film a large gas bubble with a fluid level in the lower abdominal region. This was interpreted as a ruptured bladder and later confirmed on operation.

3). Convinced of its superiority, this method of examination became our routine. However, we had many combined abdominal and chest injuries, and since our sur-

geons requested erect chests, we had the opportunity to see at least 10 cases in which we were able to demonstrate free air in the supine view of the abdominal examination, and not in the erect position of the chest examination. The reverse was never found, although many roentgenograms showed air in both views. Figures 2 and 3 are of the same patient and demonstrate that roughly twice as much air is seen in the supine as in the erect film.

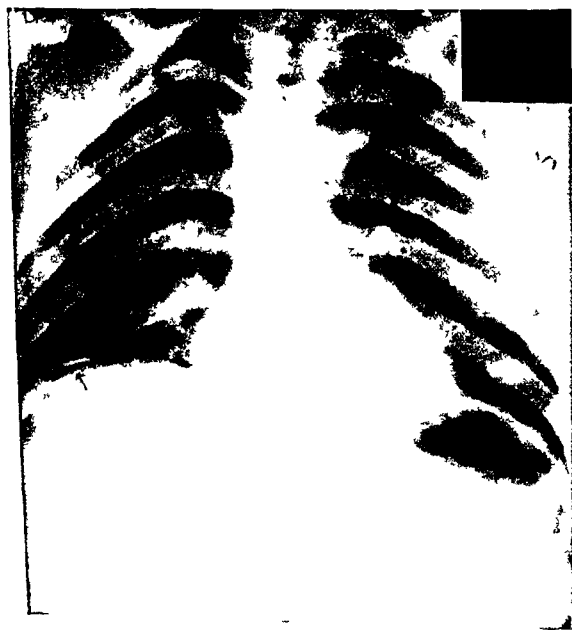


FIG. 2. Erect film showing free air under the right diaphragm.

After our technique was perfected, we found a very high correlation in over 600 examinations. Air was found in about half of these and, in all but 2 there was surgical confirmation of intraperitoneal injury. These 2 cases were very similar in that both had extraperitoneal rupture of the rectum and retroperitoneal hemorrhage, and since a colostomy was indicated, fortunately no harm was done by the laparotomy which we urged. A possible explanation for this "false" finding is the failure of the surgeons to demonstrate a small opening in the peritoneum through which air entered from the outside. Small peritoneal tears are extremely difficult to find in the pres-

ence of retroperitoneal hemorrhage. We have seen several cases of intestinal perforation or intraperitoneal hemorrhage in which a peritoneal tear could not be demonstrated at operation. Thus, it is probable that these 2 "false" positives were not false at all, and our correlation was practically 100 per cent. In many cases the

was so high that many clinically doubtful cases were spared a laparotomy because of the absence of a pneumoperitoneum.

SIGNIFICANCE OF PNEUMOPERITONEUM

Most authors feel that free air in the peritoneal cavity is the result of the escape of air from the intestines. Reinberg⁶ states



FIG. 3. The same patient taken in the recumbent position. This demonstrates that about twice as much air is seen in the recumbent view as in the conventional erect view. Note again tapering points which differentiate free air from air in bowel loops.

demonstration of free air was the deciding factor, and in a few, the only indication for a laparotomy.

Less than 10 per cent of those cases in which free air was not demonstrable were operated upon because the clinical findings urged laparotomy. This was especially so in old cases in which peritonitis was already present. It is entirely possible that the small amount of air had been reabsorbed in the few days since the original trauma. However, we had some early clinically positive cases which failed to show air, and for which there was no satisfactory explanation. The capacity of our roentgen-ray apparatus was only 15 ma. and it is possible that with better equipment, permitting faster exposure, this error might be lowered. However, even this correlation

that it has not yet been settled that air can enter the peritoneal cavity with a missile. In our experience, it is undoubtedly true that air does enter with the missile.

The peritoneal cavity is a potential or capillary space between the visceral and parietal surfaces, and it has been experimentally shown by Wagoner¹¹ in 1926 and confirmed by Salkin⁷ in 1934 that the intra-abdominal pressure is 50 mm. of water less than atmospheric pressure. Wagoner¹¹ states that the observant surgeon notices the inrush of air when the peritoneum is entered. Thus, from theoretical considerations alone, one can expect air to enter the peritoneal cavity when the peritoneum is perforated. Free air in the peritoneal cavity following a penetrating wound simply means that the peritoneum has been en-

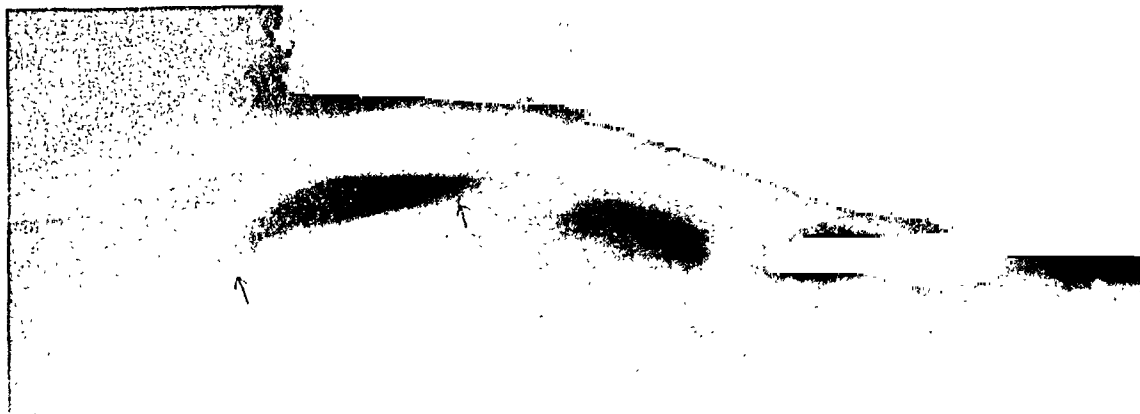


FIG. 4. Free air in a case in which no hollow viscus was perforated. The air entered through a ruptured diaphragm following a chest injury. In general, these cases show the most free air.

tered, and not necessarily that there has been visceral involvement. We have conclusive and presumptive evidence that this is true. We have seen at least 6 cases of demonstrable pneumoperitoneum in which a missile entered the peritoneum, made one or more perforations of the mesentery, and

did no other damage. We have seen many cases of demonstrable pneumoperitoneum in which a missile entered the peritoneum, lodged in the liver and did no other damage. These instances furnish conclusive proof that the pneumoperitoneum was produced by air introduced from the outside.

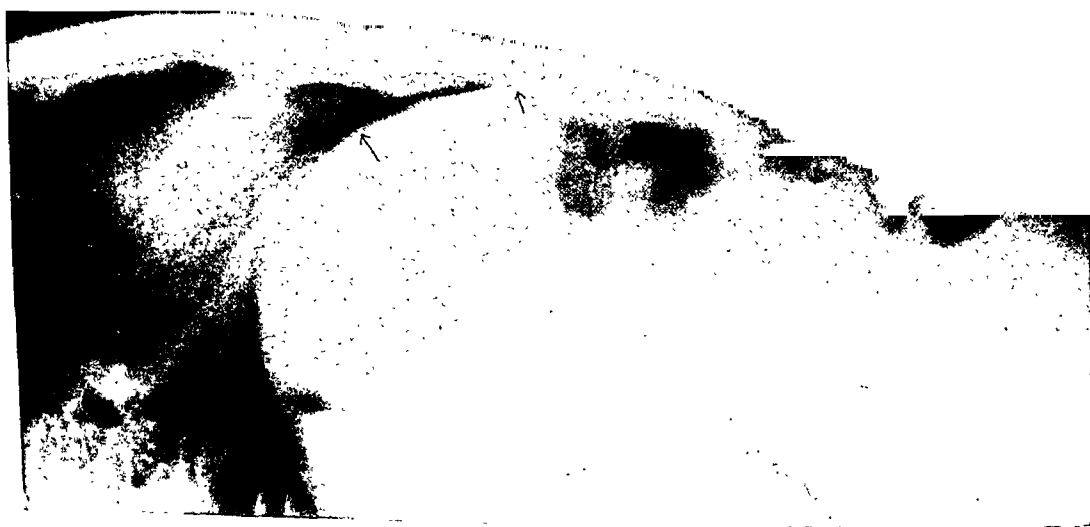


FIG. 5. This shows a large amount of air in which no hollow viscus or diaphragm was ruptured. The air was introduced from the outside.

Presumptive evidence that the free air is mostly externally introduced is obtained from several facts. There is no correlation between the amount of visible air, or the number of perforations, or the type of hollow viscus perforated. Thus, Figure 4, showing a large amount of air, is a case in which no hollow viscus was perforated, and the air came from the lung through a rup-

is partially intra-intestinal in origin, but the evidence shows that we may say with absolute certainty only that the peritoneum has been entered. This being so, is a laparotomy indicated in the presence of a pneumoperitoneum? The rarity of such an occurrence without serious visceral damage makes it imperative to explore. Then, too, it is felt that the introduction of antibac-

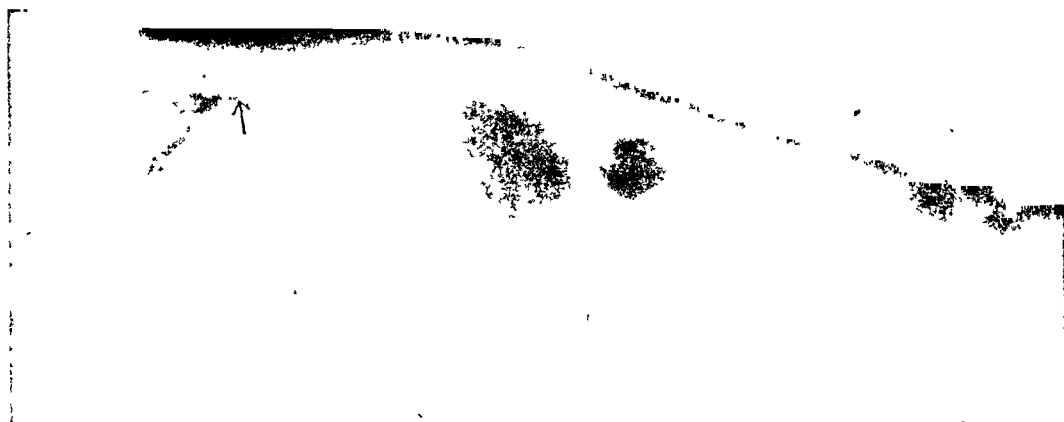


FIG. 6. This is a case in which operation disclosed two perforations in the stomach. Although a large gastric dilatation is present, nevertheless only a small amount of free air is visible. Figures 4, 5 and 6 demonstrate that there is no correlation between the amount of free air and the presence or absence of hollow viscus perforations.

tured diaphragm. In general these cases show the most air. Figure 5 is a case in which the peritoneum was entered without visceral or diaphragmatic damage. Figure 6 shows a small amount of air in which the stomach had two perforations. The anteroposterior view taken at the same time showed a large gastric dilatation which is evident on this film. We have seen a few cases of gastric dilatation with perforation in which no free air could be demonstrated. These same considerations are true for dilated perforated colons. Apparently the elasticity of the gastrointestinal wall can immediately seal a small perforation, and this probably accounts for our relatively symptom-free cases.

Undoubtedly, some of the free air we see

teriological agents and repair of the peritoneal wound is good prophylactic treatment. Most of our relatively symptom-free cases were those of peritoneal entrance in which only the liver was injured. The surgeons were tempted not to operate in these cases, but the few symptom-free cases with many intestinal perforations persuaded them to operate. Since it is felt by many that liver cases should be drained, this is an additional reason for a laparotomy and exploration.

TECHNIQUE

The patient is examined in the position in which he arrives in the roentgen department. Usually, this is supine, but we have had a few cases that came to us lying on

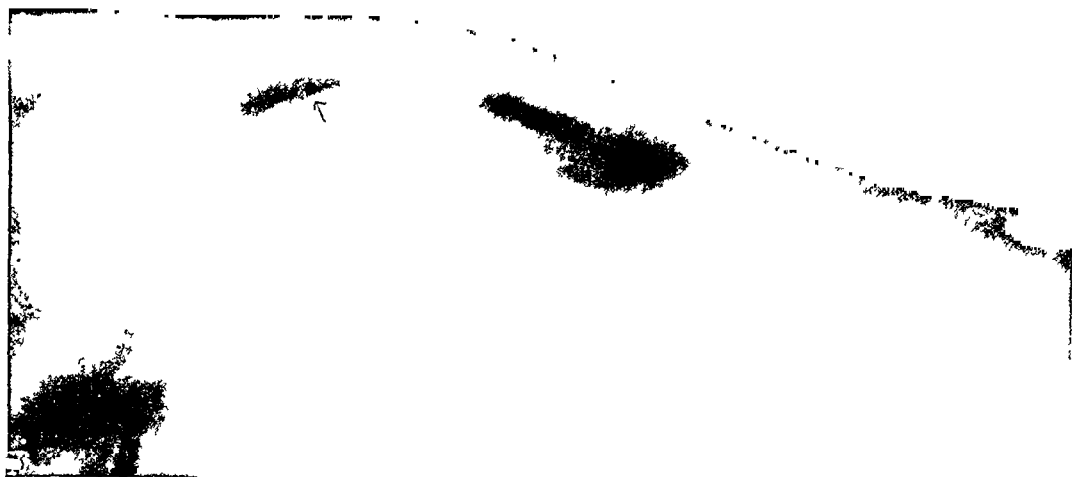


FIG. 7. In the Fowler position the free air can be confused with air in the costophrenic sulcus.

one side, and some in the prone position. When the patient is supine, a 14 by 17 inch cassette is held vertically on either side of the patient, and a lateral exposure is made with the central ray directed about 2 inches posterior to the anterior abdominal wall at the diaphragm level. The target film distance is 40 inches, and since grid lines of a stationary grid interfere greatly with interpretation, a small cone is used instead. Whether a Potter-Bucky dia-

phragm will improve the technique is problematical. A more rapid time than we have been forced to use will undoubtedly improve results. The patient is placed in a slight Fowler position in order to concentrate the free air in a small area posterior to and below the diaphragm.

DIFFERENTIAL DIAGNOSIS

The lateral roentgenogram with the patient in the supine position has not been



FIG. 8. The same case as Figure 7 in the Trendelenburg position demonstrates movability of the free air.

the preferred one, because it is felt that the identification of free air in this position is difficult. This is probably so only because there has been so little experience with this type of roentgenogram. The diagnosis is relatively easy, and extremely small amounts of free air can be positively identified. Free air in the peritoneal cavity must be differentiated chiefly from fat, air in the intestines, and air in the soft tissues. It is differentiated from air in the soft tissues by its very distinct location—it is posterior to the muscle layer of the anterior abdominal wall, and when it is concentrated cephalad by the Fowler position, it is posterior to and below the diaphragm, and follows the curve of the diaphragm. It is sharply demarcated anteriorly by the parietal peritoneum and posteriorly by the abdominal viscera. This sharp demarcation anteriorly and posteriorly is of great importance in that it readily distinguishes free air from peritoneal fat which is not sharply demarcated and fades gradually into the surrounding tissues. In addition, fat is denser than air and usually does not appear quite as black. Free air is readily differentiated from air in loops of bowel. In the latter, the air is enclosed in a limiting membrane and its upper and lower borders are consequently rounded. Free air in the peritoneal cavity characteristically terminates in tapering points. This, too, helps to differentiate free air from peritoneal fat. Occasionally, other shadows appear and may be confusing. A rib may cross the diaphragm in such a way as to produce a confusing black line. Occasionally, it is difficult to distinguish a small triangular collection of free air from the similarly shaped extremity of the anterior costophrenic sulcus. When in doubt, films taken in the Trendelenburg as well as the Fowler position show free air changing its position in contrast to fat or bowel loops which remain relatively stationary (Fig. 7 and 8).

SUMMARY AND CONCLUSIONS

1. Anteroposterior and lateral views are of little value in determining whether a

missile has or has not penetrated the peritoneal cavity.

2. Clinical symptoms and physical findings are sometimes misleading. The best roentgenological index is the presence of a pneumoperitoneum.

3. A pneumoperitoneum indicates only that the peritoneum has been entered. It does not necessarily mean visceral involvement although a laparotomy is indicated.

4. Nearly 100 per cent of all cases which show pneumoperitoneum have had peritoneal entrance. Therefore, pneumoperitoneum is a positive indication for a laparotomy.

5. In those cases in which a pneumoperitoneum could not be demonstrated, less than 10 per cent were surgically positive. This error can probably be reduced with better equipment. Nevertheless the error is sufficiently small so that some doubtful cases were spared a laparotomy by this negative finding.

6. The patient is best examined in the position in which he arrives at the roentgen department. Thus, the patient is not disturbed, the free air is not disturbed, and therefore more accurately recorded on the roentgenogram. Very minute amounts of air are thus visualized which, in many cases, cannot be seen if the position of the patient is changed for a few brief moments preceding the roentgen examination.

7. Free air is recognized by its anatomical location, its sharp demarcation, its tendency to terminate in tapering points, and its movability.

8. The points covered in the above should apply in the diagnosis of ruptured intestines from any cause as well as from perforation of the peritoneum from the outside.

I wish to express my thanks to Dr. S. Ditkowsky, formerly of the 97th Evacuation Hospital, S.M. for his valuable assistance and suggestions in the compilation of the above material.

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REFERENCES

1. DEBAKEY, M. Acute perforated gastroduodenal ulceration. *Surgery*, 1940, 8, 852; 1028.
2. LENK, R. Roentgen findings in fresh abdominal bullet injuries. *München. med. Wchnschr.*, 1916, 43, 1278.
3. ODOM, C. B., and DEBAKEY, M. Acute perforated gastric and duodenal ulcer. *New Orleans M. & S. J.*, 1940, 92, 359-366.
4. PEARCE, A. E. Diagnosis of perforated ulcer. *Am. J. Surg.*, 1943, 61, 76-78.
5. POPPER, H. Die Diagnose der Darmperforation mit Hilfe der Röntgenderchleuchtung. *Deutsche med. Wchnschr.*, 1915, 41, 1034.
6. REINBERG, S. A. X-ray diagnosis in gunshot wounds of abdominal cavity and its significance in field surgery. *Brit. J. Radiol.*, 1944, 17, 291-295.
7. SALKIN, D. Intraabdominal pressure and its regulation. *Am. Rev. Tuberc.*, 1934, 30, 436-457.
8. THAXTER, L. T. Spontaneous pneumoperitoneum in perforated peptic ulcer. *Am. J. ROENTGENOL. & RAD. THERAPY*, 1940, 44, 853-857.
9. VAUGHAN, R. T., and BRAMS, W. A. Roentgen ray in diagnosis of perforated peptic ulcer. *J.A.M.A.*, 1925, 85, 1876-1878.
10. VAUGHAN, R. T., and SINGER, H. A. Value of radiology in diagnosis of perforated peptic ulcer. *Surg., Gynec. & Obst.*, 1929, 49, 593-599.
11. WAGONER, G. W. Studies on intra-abdominal pressure; negative intra-abdominal pressure as normal condition. *Am. J. M. Sc.*, 1926, 171, 697-707.
12. WEINBERGER, M. Weitere Beiträge zur Radiographie der Brustorgane. *Med. Klin.*, 1908, 4, 584.



THE SIGNIFICANCE OF THE WIDENED SEPTUM PELLUCIDUM

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A RECENT problem in differential diagnosis presented by a widened septum pellucidum prompted a study of the significance of this finding. The purpose of this paper is (1) to discuss the importance of widening of the septum pellucidum, and (2) to consider the lesions which are said to offer difficulties in differential diagnosis.

A brief anatomic consideration of the septum pellucidum is included for the sake

lateral ventricles and the lateral layers of the septum pellucidum; anteriorly, the genu of the corpus callosum; posteriorly, the anterior limb and pillars of the fornix.

Normally, the two layers of the septum pellucidum are separated by a thin cavity of varying width, the cavum septi pellucidi or so-called fifth ventricle. The caudal portion of this cavity is termed the cavum vergae or sixth ventricle. However, these

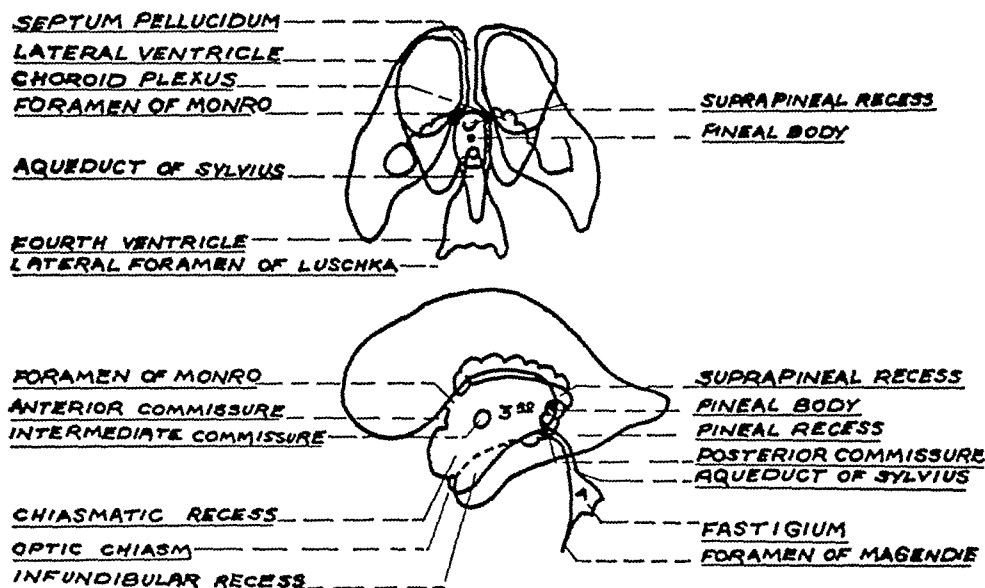


FIG. 1

of clarity (Fig. 1). The septum pellucidum (lucidum) is a thin, more or less triangular membrane consisting of two glial layers covered externally with ependyma. The septum which separates the bodies of the two lateral ventricles rostrally has the following boundaries: superiorly, the ventral surface of the body of the corpus callosum; inferiorly, the rostrum of the corpus callosum and the anterior commissure; laterally, the

structures have a different embryologic origin and are not part of the true ventricular system. They are not lined with ependyma, and may have no communication with the ventricular system.

There are two theories for the origin of the cavum septi pellucidi and the cavum vergae.³⁴ One theory contends that the cavities are produced by rapid widening of the lamina terminalis with resultant in-

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ternal tension and cavity formation during the third fetal month. The other considers the cavum to be a portion of the inter-hemispheric fissure. The lateral boundaries of this fissure are the medial aspects of the cerebral vesicles ventral to the caudally extending corpus callosum. The anatomic findings favor the second theory.

The major portion of the walls of these cavities is made up of glial tissue containing a moderate number of sclerotic fibrillary astrocytes with scant cytoplasm.³⁹ The cells lining the cavum septi pellucidi and the cavum vergae vary from low to high cuboidal in type with oval or spherical, centrally placed nuclei. Frequently, glial fibers run from the base of these cells into the surrounding glial tissue. The origin of the lining cells is in doubt. Some investigators consider them to be pia-arachnoidal inclusions but the histologic evidence is at variance with this opinion. Others suggest the possibility that they are true ependymal cells, but this also appears unlikely because the cavities are not a part of the true ventricular system, do not form a complete membrane and show no evidence of the presence of blepharoplasts when stained. Wolf and Bamford theorize that the spongioblasts lining the cavities become modified during their embryological growth to resemble ependymal cells.³⁹ The objection to this explanation is the fact that the major portion of the wall consists of a simple heavy glial mat of astrocyte fibers and occasional marginal astrocytes.

Young has comprehensively studied the comparative anatomy of the septum pellucidum in the lower forms as well as in mammals.⁴¹ In the light of his investigations, the anomalies of the septum and corpus callosum can be better understood in terms of ontogenetic and phylogenetic variations. The septum serves as an intermediate station between the olfactory bulb and hippocampus, on the one hand, and between the olfactory bulb, hippocampus and the hypothalamus, on the other. In cyclostomes, the septum is entirely absent. In selechians, a basomedial

cell group of the hemispheres directs itself toward the hippocampus as a result of neurobiotaxis. In the teleosts and ganoids, Young sees the homologue of the septum in the median nucleus, the pars commissuralis, the pars supra commissuralis and the pars intermedia. In amphibians (*Axolotl*) the septum shows a considerable increase in size, approaching the thickness of the ventricular walls. In reptiles, the septum is also well developed. In addition to the septal nuclei found in the amphibians, a nucleus accumbens septi is also present, which grows from the neostriatum into the septal region. On the other hand, the septum in birds is very thin, consisting only of frontal and fimbriated divisions. Marked development of the septum is found in the lower mammals. In the marsupials, it consists of the medial and lateral nuclei, the nucleus accumbens, the medial caudal septal nucleus, the fibers of the fornix, psalterium and secondary olfactory bundles. It lies for the most part dorsal to the corpus callosum. In higher mammals, the corpus callosum and the anterior commissure are separated and the septum principally lies ventral to the corpus callosum. In primates, the septum is elongated between the anterior commissure, fornix and corpus callosum as a result of marked growth of the latter structure anteriorly, posteriorly and dorsally. Thus are the anomalies of the septum in man reflected as normal developments in the phylogenetic scale.

Variations in the structure of the septum may be found. Infrequently, the septum pellucidum may be entirely absent.¹⁶ When present, it is usually intact although occasionally single or multiple fenestrations occur which permit direct communication between the two lateral ventricles. On the anteroposterior encephalogram, the septum pellucidum is represented by a slit-like uniform zone of increased density outlined on either side by the air-filled lateral ventricles. The normal measurements of the septum vary from 0.9 cm. to 1.5 cm. in height and from 0.2 cm. to 0.3 cm. in width.¹⁵

It is to be emphasized that the slightest degree of widening of the septum pellucidum is a significant, abnormal finding which demands further investigation. Although Pendergrass and Hodes²⁷ state that such widening should suggest the presence of a cyst, it must be stressed that this finding is associated with a variety of lesions.

giomas; (10) parasagittal tumors; (11) thalamic tumors.

It is our opinion, however, that this latter group of lesions is individually distinguishable and can readily be differentiated from the lesions in the first group.

The following group comprises the lesions which produce actual significant wid-



COMMUNICATING CYST OF
CAVUM SEPTI PELLUCIDI AND CAVUM VERGAE



NON-COMMUNICATING CYST OF SEPTUM



COMMUNICATING CYST OF SEPTUM PELLUCIDUM



SOLID TUMOR OF SEPTUM PELLUCIDUM



COMMUNICATING CYST OF CAVUM VERGAE

FIG. 2



TUMOR OF CORPUS CALLOSUM

FIG. 3

Thus, significant widening of the septum pellucidum may be produced by the following (Fig. 2 and 3): (1) cysts of the cavum septi pellucidi; (2) tumors of the septum pellucidum; (3) agenesis of the corpus callosum; (4) tumors of the corpus callosum.

In addition, other lesions (Fig. 4 and 5) have been enumerated in the literature by various authors as offering problems in differential diagnosis:^{16,25} (5) tumors of the third ventricle; (6) pinealomas; (7) tumors of the lateral ventricle; (8) midline frontal lobe tumors; (9) olfactory groove menin-

ing of the septum pellucidum and require differentiation from one another.

CYSTS OF THE CAVUM SEPTI PELLUCIDI AND CAVUM VERGAE

Two principal types of dilatation of the cavum septi pellucidi and the cavum vergae have been described by Dandy,⁹ Van Wagenen and Aird:³³ (a) communicating; (b) non-communicating.

The communicating cysts have been further subdivided into: (1) the primary

type in which there is an opening into the third or lateral ventricles presumably due to rupture of the wall because of increased intracystic pressure, and (2) the secondary or acquired type, which is associated with internal hydrocephalus.

Communicating cysts have been demonstrated frequently following encephalog-

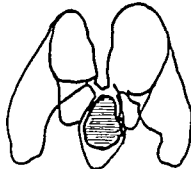
as linear densities between the air in the cavum septi pellucidi and the air-filled lateral ventricles. In the lateral view, the superimposed air contained in the anterior horns and bodies of the lateral ventricles makes recognition of the cyst difficult (Fig. 6A). However, it may be seen as a comma-shaped structure with its large di-



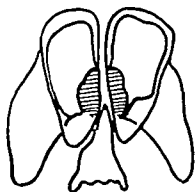
AGENESIS OF CORPUS CALLOSUM



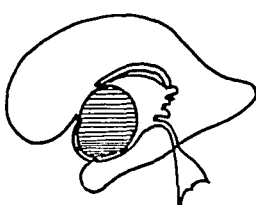
PINEALOMA



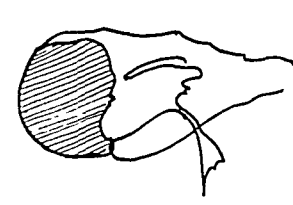
OLFACTORY GROOVE MENINGIOMA



COLLOID CYST - THIRD VENTRICLE



MID-LINE FRONTAL LOBE TUMOR



INTRAVENTRICULAR TUMOR
EPENDYMOA-OF LATERAL VENTRICLE ARISING
FROM MEDIAL WALL



FIG. 4

raphy or ventriculography. Although cysts of the cavum septi pellucidi and the cavum vergae usually occur together, a rare instance of a solitary cavum vergae cyst has been recorded by Leslie.²¹ The cysts may vary considerably in size. In the postero-anterior view (Fig. 6B), the communicating cavum septi pellucidi cyst is visualized as an air containing space separating the air-filled anterior horns of the lateral ventricles. The roof of the cyst is at the same level as the roof of the lateral ventricles. The leaves of the septum pellucidum are demonstrated

anteriorly. The anterior margin of the cyst does not extend as far forward as the anterior horns of the lateral ventricles. The tapering posterior extremity of the cyst ends in a blunt point above the junction of the aqueduct with the third ventricle.

The cavum vergae cyst can be recognized on the posteroanterior encephalogram as a triangular or oblong-shaped radio-lucent structure with the base directed inferiorly. The superior margin of the cyst is at a lower level than the roof of the lateral

FIG. 5

ventricles and the floor is also correspondingly lower than the lower border of the lateral ventricles. In the lateral view, the cavum vergae cyst is seen as an oval radiolucent structure behind the posterior limit of the cavum septi pellucidi. Because both cysts commonly occur together, they assume an hour-glass configuration in the

cles may show dilatation because of the obstruction of the foramina of Monro or the aqueduct. The radiopaque cystic mass usually encroaches upon the medial walls of the lateral ventricles in a uniform manner, and thereby produces separation of the lateral ventricles (Fig. 7). However, rarely, the encroachment of the cyst may be more



FIG. 6. Communicating cyst of the cavum septi pellucidi and cavum vergae. The slit-like cavum septi pellucidi and the triangular cavum vergae are outlined by air in the sagittal projection. The air delineates the comma-shaped area corresponding to the position of the septum pellucidum in the lateral view. Comparison of these studies with the line drawings in Figure 2 should be made.

lateral view, the area of constriction indicating the point of union.

Non-communicating cysts of the cavum septi pellucidi are rare. Pendergrass, Pancoast and Schaeffer²⁶ note that they have had no personal experience with this type of lesion, and Dyke and Davidoff¹⁷ report only one non-communicating cyst in a series of 5,000 encephalograms. Echternacht and Campbell,¹⁸ on the other hand, report three such cysts in their paper on midline anomalies of the brain. While communicating cysts may or may not produce clinical symptoms, the non-communicating variety is frequently associated with convulsions because of obstruction of the foramina of Monro and the resultant increased intracranial pressure.

In the encephalogram, the lateral ventri-

cles may show dilatation because of the obstruction of the foramina of Monro or the aqueduct. The radiopaque cystic mass usually encroaches upon the medial walls of the lateral ventricles in a uniform manner, and thereby produces separation of the lateral ventricles (Fig. 7). However, rarely, the encroachment of the cyst may be more marked on one side. Frequently, there is downward displacement of the pineal body and the roof of the third ventricle. In the lateral view, the appearance of the non-communicating cyst is similar to that described for the air-filled communicating cysts except that the former is radiopaque. For this reason, their demonstration in the lateral view is variable depending upon the size of the filling defects produced by the cysts in the lateral ventricles. While even small defects can be readily recognized in the posteroanterior projections, only sizable defects will be recognized in the lateral views.

TUMORS OF THE SEPTUM PELLUCIDUM

The tumors of the septum pellucidum are rare. A thorough search of the Ameri-

can literature has revealed a case of a mid-line ependymoma arising from the septum reported by Bailey and Cushing.² Similarly, relatively few cases are reported in the English literature. Thus, a case of a mid-line astrocytoma described as a tumor originating in the corpus callosum and invading the septum is described by Purves-Stewart.²⁸ None of the above reports is ac-

mary tumors originating in the septum are included in this grouping. Therefore, the case described by Purves-Stewart is not listed as a septal tumor.

A study of these cases failed to demonstrate any clinical or neurological findings which could be of aid in localization. Pendergrass, Pancoast and Schaeffer²⁶ state that tumors of the septum produce irregu-

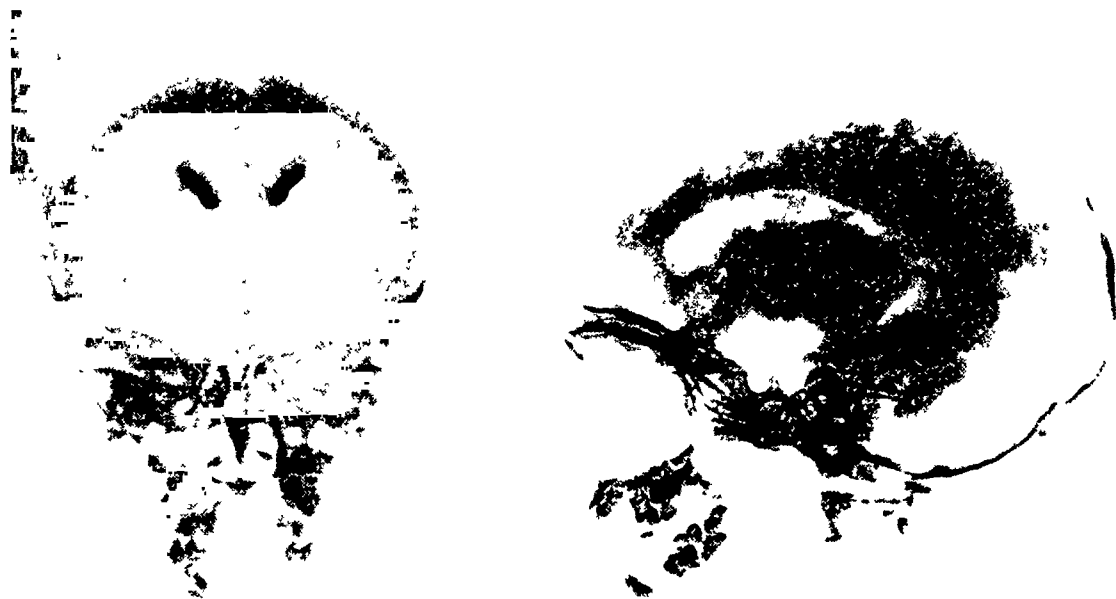


FIG. 7. Non-communicating cyst. The widened septum pellucidum (6 mm.) is shown in the sagittal views. In the lateral view, the arrows outline the density formed by the cyst which is superimposed upon the anterior horns and the anterior portions of the lateral ventricles. (This case is not confirmed.) (The illustration is reproduced with the kind permission of A. P. Echternacht and J. A. Campbell, and *Radiology*, 1946, 46, 119-131.)

panied by pneumographic studies. The photographs of the brain sections if translated into air studies would simulate a septum pellucidum cyst or tumor. Busch⁵ in 1944, reviewing the technique of intracranial surgical approaches, also described a tumor of the septum but the histopathology of this tumor is not recorded. Excluding the cases described above, only 8 lesions of this type could be found in a survey of the world literature.^{6,7,25,29,33,37,40} Five of these were reported as gliomas (one of these was classified as a fibrillary glioma), one was reported as glioblastoma, and the remaining two as fibrillary astrocytomas. Only pri-

lar distortion of the contours of this mid-line structure. Thus, they believe it possible to differentiate between tumors and cysts, since the latter produce a uniform smooth expansion of the septum. When irregularity of the widened septum is found, tumor is more likely to be present. That tumors of the septum do not necessarily produce irregularity is well demonstrated by the first case (Case 1). Because of the rarity of these tumors and the unique roentgen findings demonstrated following pneumographic studies, the first case is reported in detail.

CASE 1. C. G., a male, aged thirty-four,

chemist, was admitted to the Grace Hospital on December 14, 1942, because of headaches of three months duration. The headaches, insidious in onset, were most frequently frontal, but were occasionally noted in the occipital and biparietal areas as well. Ten days prior to admission, persistent projectile vomiting appeared. Two days later, during a conversation, he suddenly lost consciousness for an hour. Upon responding, he was dazed and could not remember the period of unconsciousness. For the past three months also, there had been impairment of memory for recent events and some personality changes characterized chiefly by irritability.

Seven months ago, the patient was placed on an ulcer regimen by his physician because of nausea, anorexia and a weight loss of 22 pounds. No vomiting was present at that time and he soon regained the lost weight.

The past medical history included measles, pneumonia, bronchitis and pertussis in childhood, a sacroiliac strain in 1939 and removal of

a lipoma of the right shoulder in 1938. A grim coincidence was the patient's statement that his father had a "tumor at the base of the brain" removed. The details of the operative procedure could not be obtained.

Physical examination was essentially negative except for hyperactive but symmetrical deep reflexes and a positive bilateral Hoffman sign. No Babinski was present and the eye grounds were normal. The significant laboratory findings were as follows: the Wassermann reaction was negative; the red blood cell count was 4.54 million per cu. mm. with 80 per cent hemoglobin; the white blood cell count was 12,000 per cu. mm. with 70 per cent segmented polymorphonuclear leukocytes, 7 per cent non-segmented polymorphonuclear leukocytes, 17 per cent lymphocytes and 6 per cent monocytes. The blood sugar was 92 mg. per 100 cc. The non-protein nitrogen was 35 mg. per 100 cc.

The lumbar puncture on December 15, 1942, showed an initial cerebrospinal fluid pressure of

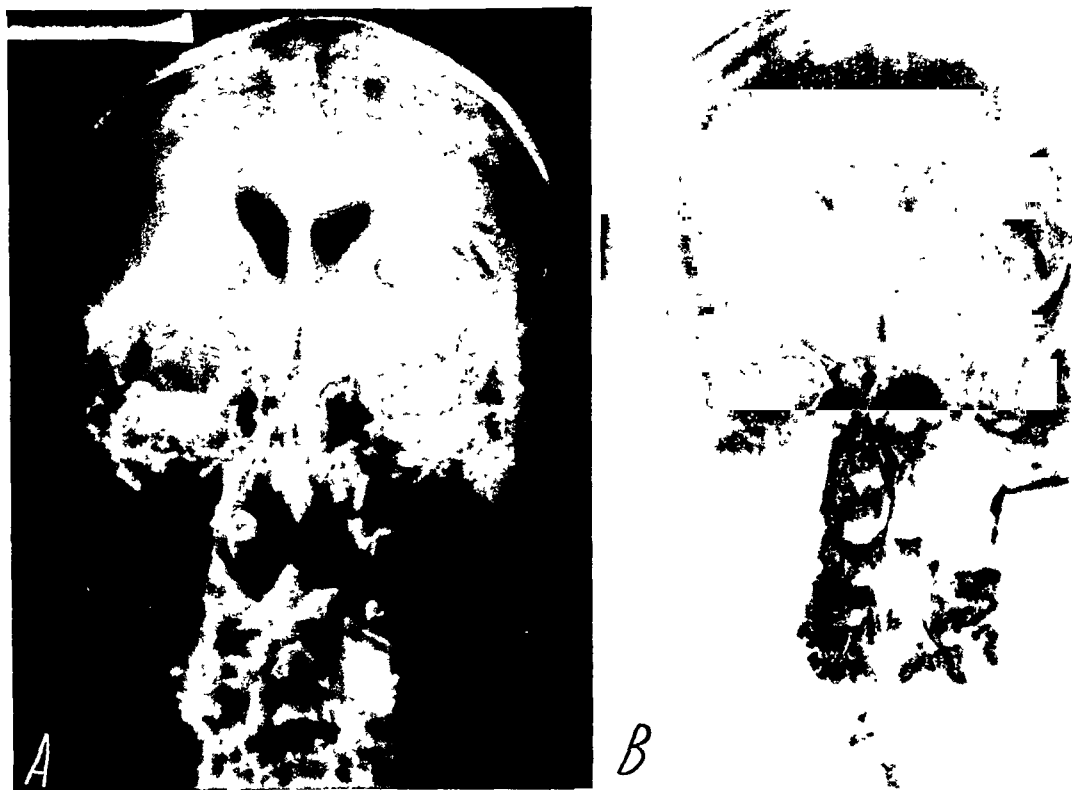


FIG. 8. Case 1. Tumor of the septum pellucidum. The posteroanterior (A) and anteroposterior (B) projections are shown. The symmetrically widened septum pellucidum measured 6 mm. in the posteroanterior view. Note the marked similarity in the posteroanterior view of the non-communicating cyst in Figure 7. Pathologic examination demonstrated a diffuse fibrillary astrocytoma of the septum in this case.

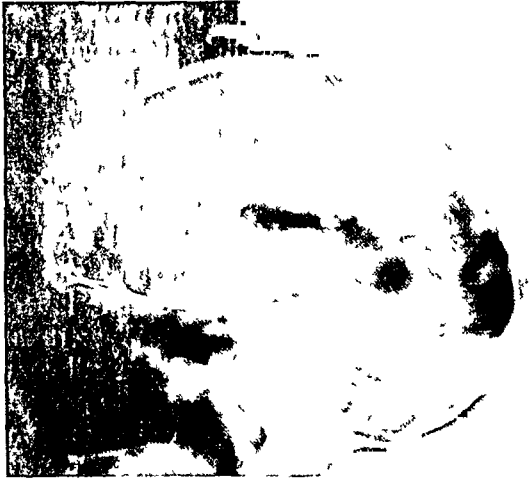


FIG. 9. Case I. The lateral view demonstrates the irregular scalloped defects in the roof and the anterior horns of the lateral ventricles.

525 mm. H_2O with no block. The fluid was translucent, colorless, contained 1 monocyte per high power field and a total protein of 14 mg. per 100 cc. The colloidal gold test was negative.

Roentgen examination of the skull at this time showed some decalcification of the posterior clinoid tips, increased digital markings and slight posterior and downward displacement of the pineal body.

Re-examination of the ocular fundi on December 20 showed definite blurring and congestion of the superior nasal margin of the right fundus. On December 30, the patient complained of severe headache. Fundoscopic examination at this time showed early choking of both discs and visual field studies revealed full peripheral range with small "blind spots" bilaterally. Ventriculography was attempted on January 7, 1943, but was not entirely satisfactory because of the introduction of an insufficient quantity of air. This study was repeated on January 17 and definite widening of the septum pellucidum was noted, suggesting the diagnosis of an infiltrating tumor in this area (Fig. 8 and 9). Another lumbar puncture on January 19 revealed an initial pressure of 280 mm. H_2O with a cell count of 6 lymphocytes per high power field and a total protein of 51 mg. per 100 cc.

On January 22, an electroencephalogram showed 8-9 per second and 5-6 per second wave frequencies mixed in all leads. The left occipital, and to a lesser extent, the left temporal leads

showed numerous 2-3 per second waves on monopolar recording. On bipolar recording, there was out-of-phase activity pointing to a left occipital focus. Lumbar puncture was repeated on February 3 because of the unusual severity of the patient's headaches. The initial cerebrospinal fluid pressure was 220 mm. H_2O and the total protein was 30 mg. per 100 cc. On February 9, ventriculography was repeated but showed no significant change since the previous study. A left frontal flap was then made, the dura opened and the brain explored. No abnormalities could be found in the prefrontal area, at the base of the brain or between the hemispheres. Internal decompression was deemed advisable and the left prefrontal lobe was resected.

The patient died on February 11, 1943. At autopsy, gross examination of the brain, after fixation in formalin, showed only uniform diffuse widening of the septum pellucidum. No localized tumor masses were noted. Numerous microscopic sections, however, demonstrated the presence of extensive tumor invasion with coalescent sheets of fibrillary astrocytes. In some areas, a glial stroma between the astrocytes could be seen.

Comparative illustrations demonstrate that the appearance of the widened septum pellucidum produced by tumor and non-communicating cysts can be indistinguishable (compare Fig. 7A and 8A). It is obviously of considerable importance, therefore, to be able to differentiate these lesions because of the marked difference in prognosis. Dandy,^{8,9} and Echternacht and Campbell¹⁸ have reported cases in which non-communicating cysts have been transformed into the communicating variety as a result of accidental puncture of the cyst wall by the exploring trocar. We believe that such a procedure is of paramount diagnostic importance and should be employed in any mass lesion of the septum visualized as an area of increased density in the air studies. In this way, a non-communicating cyst may be converted into a cyst of the communicating type, thus permitting easy differentiation.

CASE II. M. S., male, aged thirty-five, was admitted to the Neurological Institute on Feb-

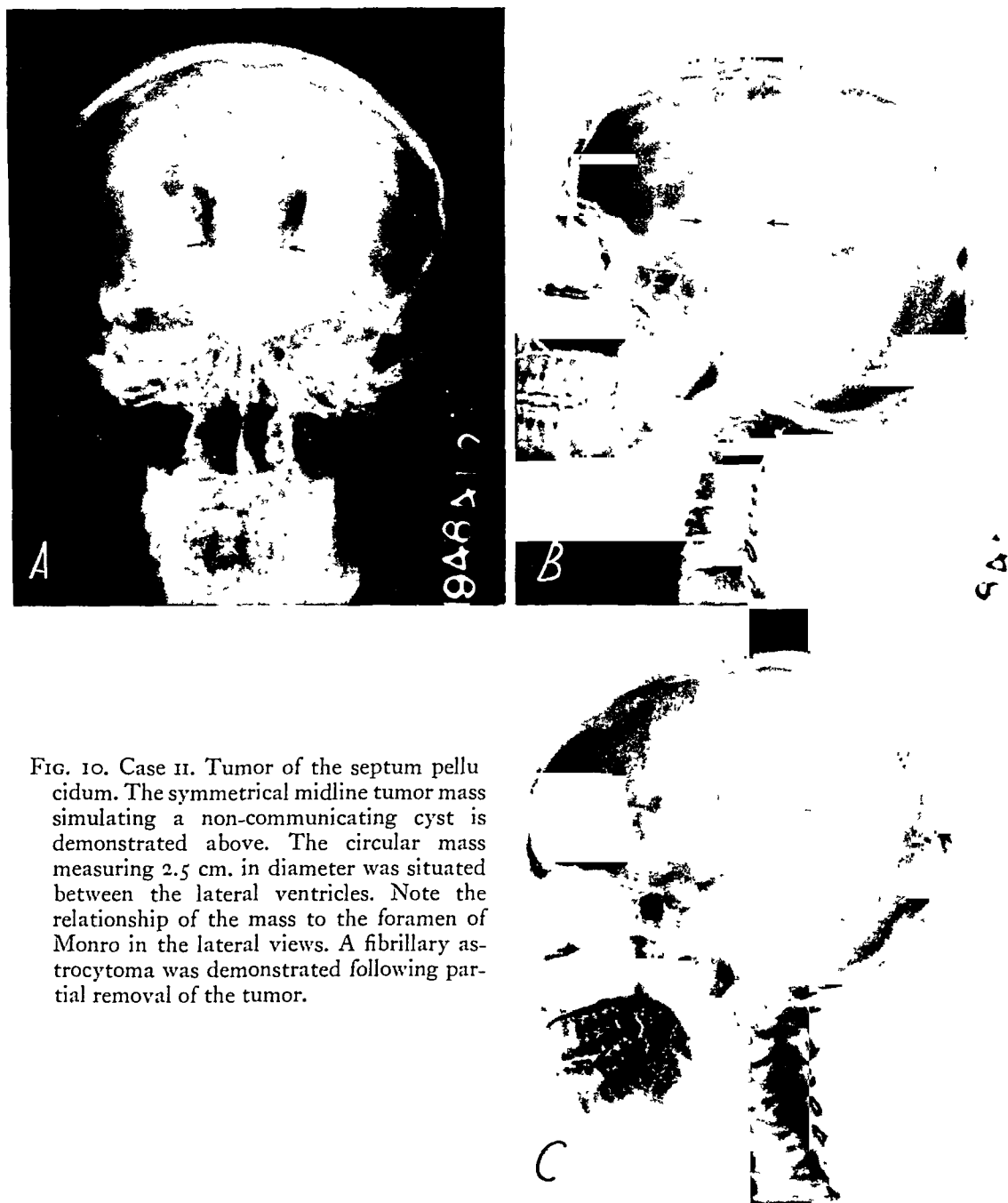


FIG. 10. Case II. Tumor of the septum pellucidum. The symmetrical midline tumor mass simulating a non-communicating cyst is demonstrated above. The circular mass measuring 2.5 cm. in diameter was situated between the lateral ventricles. Note the relationship of the mass to the foramen of Monro in the lateral views. A fibrillary astrocytoma was demonstrated following partial removal of the tumor.

ruary 13, 1931, complaining of intermittent headaches since 1922, which had been steadily increasing in severity, particularly for the five weeks prior to admission. He had had one generalized epileptic seizure in 1922. Five weeks prior to admission, he first noticed dizziness followed by impaired hearing in the right ear. Three weeks later, before admission, he began to have blurred vision accompanied by vomiting five days before entering the hospital. There

was a weight loss of 10 pounds in the two weeks prior to admission.

The physical examination showed uncertainty of gait, no ataxia, fine tremors of fingers of the right hand, exaggerated reflexes, bilateral papilledema with hemorrhages and impaired hearing.

The spinal fluid globulin and Wassermann reaction were negative. The protein was 24 mg. per 100 cc.



FIG. 11. Case III. Tumor of the septum pellucidum. The tumor produced a concave impression in the medial margins of the ventricles. Both lateral ventricles were dilated because of the obstruction at the foramen of Monro. This was interpreted as a non-communicating cyst of the cavum septi pellucidi and an unspecified glioma was found at operation.

Ventriculographic studies demonstrated a sharply defined circular mass 2.5 cm. in diameter lying between the lateral ventricles at the foramen of Monro (Fig. 10).

At operation, on March 9, 1931, four small nodules varying from 5 to 10 mm. in size were noted in the leptomeninges, each lying adjacent to a large vein. At the time of operation, these were reported as lymphosarcoma, and therefore the flap was closed without making any attempt to explore the mass in the lateral ventricles. Subsequent histopathologic study did not confirm the diagnosis of lymphosarcoma.

More recent review of the slides of the specimens taken at this operation reveals that these nodules were probably arachnoid cell clusters and not lymphosarcoma.

The patient was given roentgen treatment directed to the interventricular mass, as follows:

Between March, 1931, and June, 1934, the patient received a total of 9,300 r to the right frontoparietal area (centered for foramen of Monro); 8,250 r was delivered to the left frontoparietal area and 4,500 r to the midline forehead. Treatments were given in doses varying from 300 to 600 r (measured in air) per field per day, in series varying from 750 to 2,400 r total per field. The usual interval between series was two to three months.

Following this, he did well until 1933, at which time he was readmitted because he had

had a convulsion, during which his eyes had turned to the left. This had occurred following a roentgen treatment. During this admission, several nodules over the anterior aspects of the thighs were biopsied, on the possibility that neurofibromata might be present, but these nodules proved to be lipomata. He had no further convulsions and was discharged in two weeks.

In June, 1934, he was readmitted because of frequent convulsions, impaired memory, and emotional instability.

A ventriculogram showed little change since the original study in 1931. The interventricular mass was present as before and essentially the same size. It was interpreted as a non-communicating cyst of the septum pellucidum.

Operation on April 15, 1935, revealed a reddish-brown tumor mass along the inferior margin of the septum pellucidum. It was partially removed, its position making complete removal impossible.

The histopathologic examination revealed fibrillary astrocytoma.

The patient did well postoperatively, but the mental condition did not improve. He died in another hospital the following year. Autopsy was not performed.

It seems fair to assume, in this case, that the failure of the tumor to increase in size in four years (as judged by air studies) was due to the roentgen treatment.

CASE III. M. L., female, aged twenty-eight, was admitted to the Neurological Institute on May 31, 1932, because of frontal headaches. These had started gradually about six months prior to admission, and had been associated with a painful sensation over the eyes. Two months prior to admission, she had become generally weak, experienced some difficulty in walking, and complained of ringing in the ears. One month prior to admission, she had to give up her work because of weakness and drowsiness.

Physical examination revealed a slight over-adduction of the right leg in walking, slight awkwardness of the left hand, but no abnormal reflexes. The fundi showed blurring of the discs with distended veins and rather small arteries; one diopter of papilledema was noted. The visual fields showed enlargement of the blind spots. There was a slight right lower facial weakness.

The ventricular spinal fluid showed a protein of 76 mg. per 100 cc., and 2 plus globulin. The serology was negative.

Roentgenograms of the skull showed a slightly enlarged sella with atrophic dorsum indicating increased intracranial pressure.

Ventriculographic studies showed that both lateral ventricles were separated, apparently by a mass approximately 4.5 cm. in diameter, which caused a concave impression in the medial margins of the ventricles. The mass lay in the position of the septum pellucidum and was interpreted as a non-communicating cyst of the cavum septi pellucidi. Both lateral ventricles were dilated, apparently due to the obstruction at the foramen of Monro (Fig. 12).

On June 14, 1932, a right osteoplastic flap was turned, and exploration of the septum pellucidum was completed. Deep in the midline, a tumor mass was encountered.

On puncture of the mass, there was so much venous bleeding encountered that it was considered unwise to proceed. When bleeding was controlled, the flap was closed.

The biopsy specimen was unsatisfactory for specific diagnosis, but there was no doubt that it was neoplastic tissue. The pathologist con-

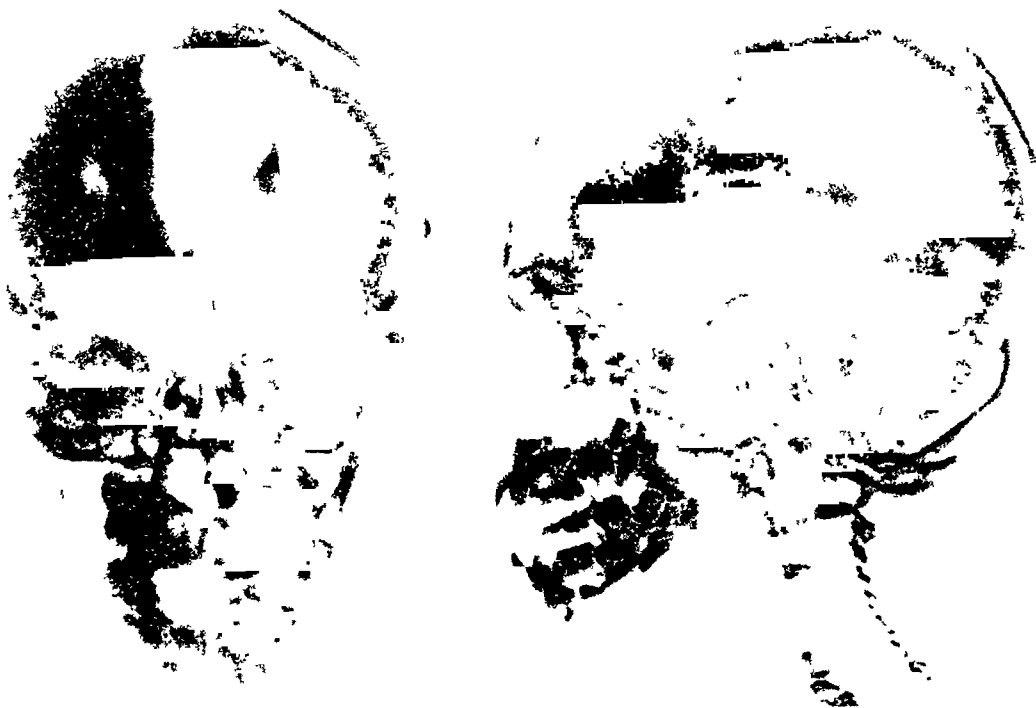


FIG. 12. Complete agenesis of the corpus callosum. The sagittal projection demonstrates the separation of the lateral views, the concavity of the medial borders and pointing of the dorsal margins of the lateral ventricles and the dilatation and elevation of the third ventricle. Interhemispheric and subdural air obscures the lateral view so that the radial arrangement of the sulci cannot be seen satisfactorily.

sidered oligodendroglioma as the most likely diagnosis but the specimen was inadequate for definite classification.

The summary of the roentgen therapy follows: From June, 1932, to October, 1932, she had a total of 2,000 r to the right frontal area; 2,000 r to the left frontal area, and 1,600 r to the mid forehead. This was given in two series, one in June and one in October. Treatments were given at the rate of 200 r (measured in air) per day.

After operation and roentgen treatment, the patient was remarkably improved, and remained free of complaints during the next six years. The patient ceased to return for follow-up visits in 1938.

Although the histopathology of this tumor is not clear, it seems probable that it was a slow-growing glioma, that is, either oligodendroglioma or astrocytoma.

It is important to note that although Cases II and III were both confirmed tumors, the preoperative roentgen diagnosis in each case was that of cyst of the septum pellucidum. It is our impression that the astrocytoma or oligodendroglioma whether originating in the lower part of the corpus callosum or in the septum proper is more likely to produce a symmetrical midline tumor mass resembling a non-communicating cyst than an ependymoma. This is borne out by the astrocytomas presented by Purves-Stewart and in this report. These masses were midline and symmetrical. On the other hand, 2 cases of midline ependymoma which have been operated upon at the Neurological Institute (Dr. Benno Schlesinger) and observed by one of us (L.C.C.) have been asymmetrical. This asymmetry is best explained by the fact that ependymomas must arise from one side or the other of the septum. The tumor probably grows freely filling the ventricle on the side of origin. When the tumor is impeded by the relative resistance of the lateral wall of the ventricle, the mass then bulges into the opposite ventricle. As the ependymomas reach sufficient size, however, they may fill both ventricles but are somewhat larger on the side on which they first arose and grew.

AGENESIS OF THE CORPUS CALLOSUM

The corpus callosum develops as an outgrowth of the lamina terminalis between the third and fifth fetal months. During the first three weeks of fetal development, the cerebral hemispheres and the ventricular system form a single structure. From the fourth to the twelfth week, the longitudinal fissure appears, dividing the cerebral hemispheres in two. During the fourth month, the anterior commissure and genu of the corpus callosum are differentiated. Various degrees of maldevelopment of the corpus callosum may occur, depending upon the stage of arrest in embryonic growth. These abnormalities are frequently associated with defects in the neighboring structures. Thus, the anomaly may range from a minor defect in one portion of the corpus callosum to absence of the entire corpus. Absence of the anterior commissure, portions of the fornix and the septum pellucidum have also been reported in these cases.

The characteristic pneumographic changes indicative of agenesis of the corpus callosum have been described by Davidoff and Dyke¹³ as follows: (1) marked separation of the lateral ventricles; (2) angular dorsal margins of the lateral ventricles; (3) concave mesial borders of the lateral ventricles; (4) dilatation of the caudal portions of the lateral ventricles; (5) elongation of the interventricular foramina; (6) dorsal extension and dilatation of the third ventricle; (7) radial arrangement of the mesial cerebral sulci around the roof of the third ventricle and extension of these sulci through the zone usually occupied by the corpus callosum.

The radially arranged convolutions and sulci found on the medial aspect of the brain associated with agenesis are thought to represent the anomalous preservation of these intracranial structures existing prior to the formation of the corpus callosum in the third month of fetal life.

Bunts and Chaffee⁴ state that agenesis of the corpus callosum may be confused with a cavum septi pellucidi communicating

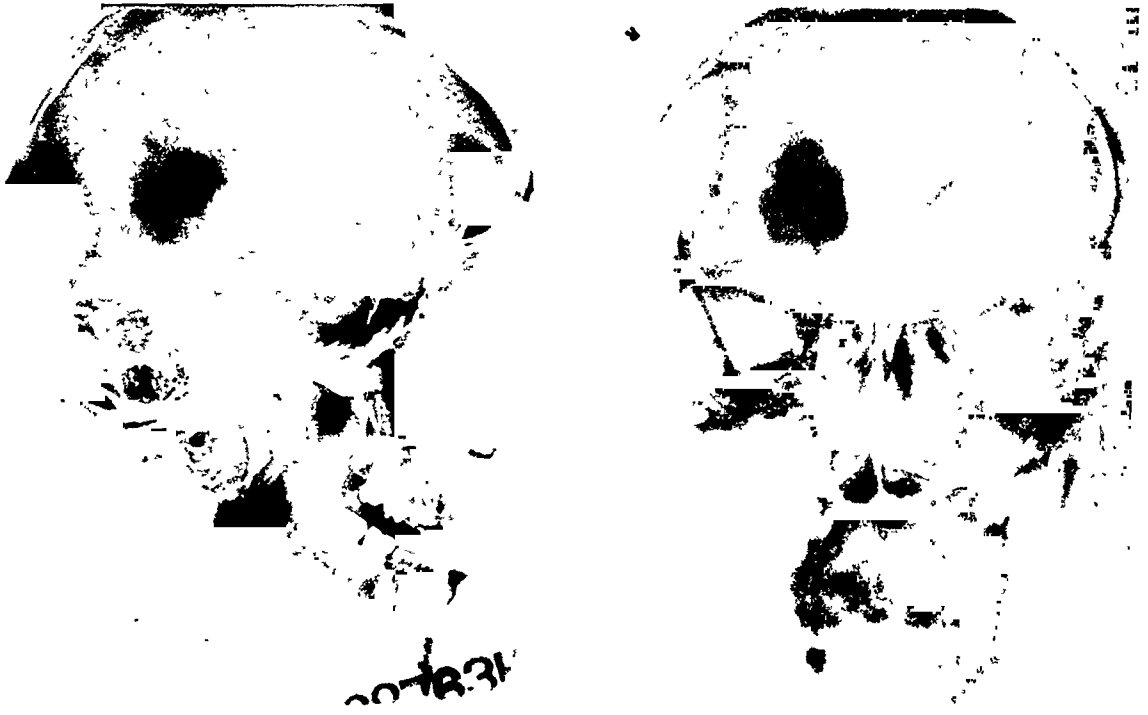


FIG. 13. Tumor of the corpus callosum. The anteroposterior projection following ventriculography shows marked separation of the lateral ventricles. In the lateral projection, deformity and obliteration of the anterior portions of the lateral ventricles is shown. Pathologic classification of an astrocytoma following transfrontal craniotomy confirmed the preoperative diagnosis.

cyst. Davidoff and Dyke,¹³ and Hyndman and Penfield²⁰ have reported cases of agenesis of the corpus callosum which were misinterpreted as cysts of the cavum septi pellucidi. However, the angular dorsal margins of the lateral ventricles, the dilatation of the caudal portions of the lateral ventricles and radial arrangement of the mesial cerebral sulci should serve to differentiate agenesis of the corpus callosum from communicating cysts of the cavum septi pellucidi.

Sosman³² has made the interesting observation that agenesis of the corpus callosum may be associated with a midline intracranial lipoma.

TUMORS INVOLVING THE CORPUS CALLOSUM

While congenital anomalies arising from the midline structures are rare, it is well to recognize that tumors originating in the corpus callosum are likewise uncommon.

Thus, Dyke and Davidoff¹⁷ have made the diagnosis of a corpus callosal tumor 8 times in a series of 3,000 air studies. Pathologic verification of the tumor growth in 5 cases of this series is reported. Dyke and Davidoff enumerate the characteristic pneumoencephalographic findings diagnostic of tumors of the corpus callosum as follows: (1) separation and asymmetrical distortion of the lateral ventricles without displacement of the ventricular system as a whole to either side; (2) a sharply circumscribed defect in the dorsal margin of one or both lateral ventricles; (3) occasional failure of one lateral ventricle to fill with gas; (4) distortion of the sulci and convolutions on the medial aspect of the brain; (5) deformity or obliteration of the dorsal and rostral portions of the third ventricle.

Since this tumor arises above, and infiltrates between, both lateral ventricles, separation of the lateral ventricles without lateral displacement of the ventricular sys-

tem is found (Fig. 13). If the growth of the tumor is equal in all directions, the maximum separation of the lateral ventricles is noted in their dorsal portions. However, if the principal expansion of the tumor is directed ventrally, then the lateral ventricles are equally separated for the entire ventro-dorsal distance. Since the neoplastic growth does not follow an orderly pattern, one side is usually involved more extensively than the other, thus accounting for the asymmetrical separation of the lateral ventricles in the anteroposterior view. The occasional failure of one lateral ventricle to fill with gas following unilateral ventriculography or pneumoencephalography is the result of obstruction to one or both foramina of Monro when the tumor is localized to the rostral portion of the corpus callosum. If the air enters the third ventricle, a deformity in the dorsal and rostral portion of this structure may be seen. The distortion and dorsal displacement of the angulate and callosal sulci add further evidence to the presence and size of these tumors.

DIFFERENTIAL DIAGNOSIS

These lesions are not associated with any characteristic neurologic syndromes. Therefore, it is of paramount importance to recognize the pneumoencephalographic changes which permit differentiation, since this is the only means by which the proper diagnosis can be established.

Tumors of the corpus callosum can be distinguished from communicating cysts of the cavum septi pellucidi with comparative ease because of the presence of air in the midline cystic cavity. In addition, the following characteristics, which are pathognomonic of corpus callosal tumors, serve to differentiate these lesions from non-communicating as well as communicating septal cysts:

(1) Callosal tumors produce asymmetrical, irregular separation of the lateral ventricles in the anteroposterior view. This is in contradistinction to the smooth, symmetrical, concave mesial borders of these ventricles found in septal cysts.

(2) The deformity of the dorsal aspect of the lateral ventricles and the changes in the callosal and cingulate sulci seen with callosal tumors in the lateral view are not found in cases of septal cysts.

In discussing tumors of the septum pellucidum and the corpus callosum, it is important to emphasize that it is difficult to classify these tumors accurately. This presentation is based strictly on a classification by localization. Thus, a tumor from the adjacent lobes invading the corpus callosum, or even a septal tumor invading the corpus callosum could all be classed as a corpus callosal tumor. Similarly, this is true of the septum pellucidum. Unless a tumor is localized strictly to one structure i.e. the corpus callosum or the septum, it may be impossible to determine its site of origin by any method of examination including autopsy. The histopathological types of tumor in these regions are the same as in other parts of the brain.

Primary tumors of the septum and non-communicating cysts may produce a similar roentgen appearance. Therefore, the diagnostic criteria enumerated under non-communicating septal cysts also serve to differentiate these lesions from tumors of the corpus callosum. It is important, here, to re-emphasize the importance of puncture of a mass lesion of the septum pellucidum by means of a trocar in order to permit entrance of air into a non-communicating cyst, thereby differentiating it from a tumor of the septum pellucidum.

Differentiation of agenesis of the corpus callosum from callosal tumors may be established by the following characteristics:

(1) In agenesis, the separation of the lateral ventricles is symmetrical whereas corpus callosal tumors produce asymmetrical separation of the lateral ventricles.

(2) The dorsal margins of the lateral ventricles are characteristically pointed and the caudal portions of the lateral ventricles are dilated in the anteroposterior view in agenesis, whereas these findings are not present in callosal tumors.

(3) The sulci in the medial aspect of the

brain course ventrodorsally through the zone normally occupied by the corpus callosum.

(4) The defect on the dorsal aspect of the lateral ventricles seen in the lateral view in callosal tumors is absent in agenesis.

(5) In the plain roentgenograms of the skull, evidence of increased intracranial pressure may be noted in tumors of the

TUMORS OF THE THIRD VENTRICLE

A number of cases of tumors of the third ventricle has been reported by Dandy,^{8,11} Zimmerman and German⁴² and Davidoff and Dyke.¹⁴

The benign tumors of the third ventricle are usually of three varieties: (1) so-called colloid cysts in which the cyst wall is composed of cuboidal or columnar ciliated epi-



FIG. 14. Colloid cyst of the rostral portion of the third ventricle. The midline mass lying in the rostral portion of the anterior portion of the third ventricle is shown in the posteroanterior and lateral views. Obstruction in the foramina of Monro has produced the dilatation of the lateral ventricles.

corpus callosum while such changes are absent in agenesis.

(6) The third ventricle is elongated and high.

Although various investigators have included the second group of tumors among the lesions which offer differential diagnostic problems, they can be distinguished from the midline lesions described in the first group. In addition to the conventional pneumographic roentgen studies, the diagnosis of these lesions is facilitated by laminagraphy^{19,23,35} and the various positional techniques recommended by Twining³⁶ for visualizing the third ventricle and aqueduct.

thelium and the stroma consists exclusively of collagenous connective tissue; (2) bucconeural pouch tumors or adamantinomas in which the histological structure demonstrates the cyst wall to be composed of a multilayered squamous epithelium arranged in papillary processes; (3) epidermoid cysts in which the cyst wall is composed of stratified squamous epithelium and masses of lipoid-containing phagocytes, cellular debris and cholesterol crystals.

Since many of these tumors are of benign character and amenable to cure following surgical intervention, the diagnosis of such lesions is of the utmost practical impor-

tance. On the anteroposterior encephalogram, the appearance produced by colloid cysts of the third ventricle may superficially resemble that found in communicating septal cysts. This is due to the fact that the tumor produces obstruction and internal hydrocephalus with resultant dilatation and upward displacement of the third ventricle. The latter structure may be mis-

increased density in the anterior portion of the third ventricle which can readily be made out.

When ventriculography is performed and a single puncture is done, air may fail entirely to pass into the other lateral or third ventricle, or may do so with considerable difficulty. There may be deviation of the septum pellucidum to one side and again



FIG. 15. Pinealomas. The midline mass situated in the posterior portion of the third ventricle is demonstrated by posteroanterior and lateral views. The crescentic bulge in the posterior portion of the third ventricle is well demonstrated in the lateral view. Note the calcification in the pineal area.

taken for a cyst of the septum pellucidum. In these hydrocephalic lateral ventricles due to obstruction of the foramen of Monro, there may be a perforation of the septum pellucidum. Hence, free passage of air between the lateral ventricle does not exclude obstruction at the foramen.

However, closer inspection of the anteroposterior films frequently demonstrates a filling defect in the third ventricle.¹⁴ The border of the air posterior to the filling defect has a straight or concave margin. There is no problem in differential diagnosis on the lateral films. In these films, the filling defect is represented by an area of

the filling defect in the anterior portion of the third ventricle can be noted. When double ventricular puncture is done, the sharp demarcation of the air shadow in the foramen of Monro as well as the filling defect can be seen.

PINEALOMAS

These tumors usually present characteristic changes. Because of their location in the midline of the posterior wall of the third ventricle just above the aqueduct, these masses encroach upon and deform the posterior junction of the ventricle obliterating the suprapineal recess. The tumors

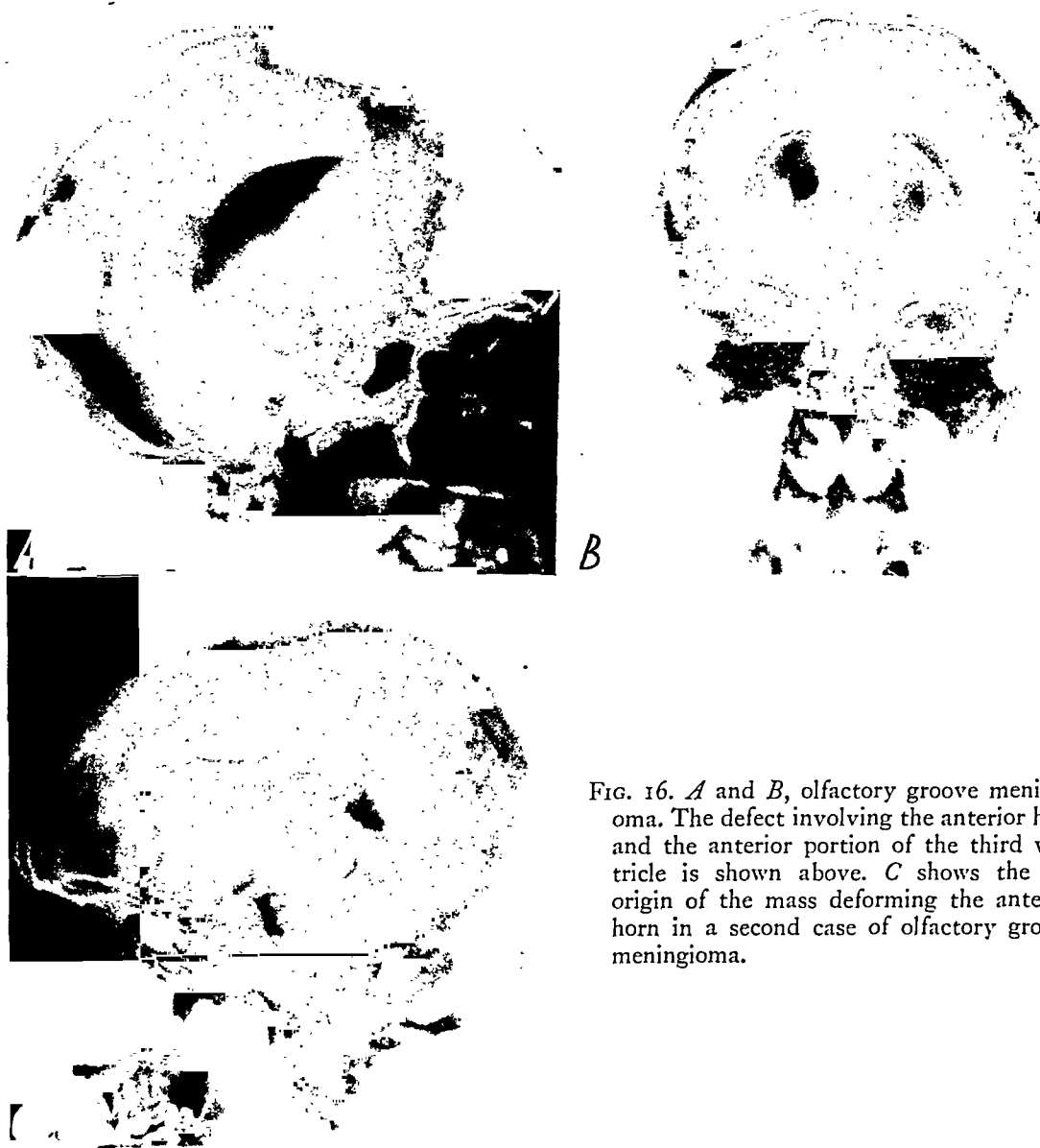


FIG. 16. *A* and *B*, olfactory groove meningioma. The defect involving the anterior horn and the anterior portion of the third ventricle is shown above. *C* shows the low origin of the mass deforming the anterior horn in a second case of olfactory groove meningioma.

form a filling defect or a crescentic bulge into the posterior portion of the third ventricle.¹⁵ The early obstruction of the aqueduct causes the obstructive hydrocephalus. The resultant obstructive hydrocephalus produces symmetrical expansion and separation of the lateral ventricles. The recognition of the filling defects in the posterior portion of the third ventricle in the lateral view can readily be made if complete filling of this ventricle with air has been obtained. The employment of positional maneuvers recommended by Twining, the head ma-

nipulations advised by Lysholm²⁴ and laminagrams are important for the visualization of the lesions in this area. The presence of calcification in the pineal tumor is also of localizing value.

TUMORS OF THE LATERAL VENTRICLES

Tumors originating from the medial aspect of the lateral ventricles separate the lateral ventricles and encroach upon the third ventricle. Ependymomas arising in these areas may produce internal hydrocephalus by blocking off the foramina of

Monro. Thus, they can be confused on the posteroanterior roentgenogram with a non-communicating cyst, or tumor of the septum. Usually, however, they are asymmetrical and deform only a single ventricle. In the lateral view, an opaque filling defect in one or the other air-filled ventricles serves to differentiate this lesion from primary lesions of the septum.

MIDLINE FRONTAL LOBE TUMORS

Frontal lobe tumors extending beyond the midline and tumors arising from the falx cerebri anteriorly produce separation of the anterior horns of the lateral ventricles which may be indistinguishable on the posteroanterior encephalogram from the appearance due to septal lesions. In the lateral view, however, characteristic filling defects in the anterior horns can be seen which aid in the differentiation of these lesions.

OLFACTORY GROOVE MENINGIOMAS

These tumors, with their associated hyperostosis and other characteristic bone changes, should cause no confusion, even though they may grow to a large enough size to produce some separation of the anterior horns of the lateral ventricles.

It is important to point out that the origin of the olfactory groove meningiomas is below the level of the lateral ventricles whereas septal tumors are at the level and callosal tumors are above the level of the ventricles. The low origin of the olfactory groove meningiomas is usually demonstrable in the type of defect in the anterior horn and anterior part of the third ventricle (Fig. 16).

PARASAGITTAL TUMORS

Tumors arising dorsal to the corpus callosum produce displacement of the ventricles to the side opposite the tumor. The lateral ventricles are not separated and the homolateral ventricle is flattened and depressed.

TUMORS OF THE THALAMUS

Tumors of the thalamus which produce bilateral equal invasion obliterate the

posterior portion of the third ventricle. This is well demonstrated in the lateral view. The suprapineal recess, however, is not deformed. In the sagittal view, there is separation of the lateral ventricles which superficially resembles a non-communicating septal cyst. Moreover, it should be noted that most thalamic tumors are unilateral and these, of course, present no problem.

SUMMARY

- (1) The embryology, comparative anatomy, normal anatomy and measurements of the septum pellucidum are reviewed.
- (2) The significance of widening of the septum pellucidum and the various lesions which may produce this finding are discussed.
- (3) Two groups of lesions are presented: (a) The first group includes cysts of the cavum septi pellucidi, tumors of the septum pellucidum, agenesis of the corpus callosum and tumors of the corpus callosum. The criteria for the roentgen diagnosis of these lesions is noted and their differential diagnosis is discussed. (b) The second group is composed of a heterogeneous collection of lesions which offer few problems in differential diagnosis. The characteristic roentgen features of the latter group of lesions are also presented.
- (4) Three cases of tumor of the septum pellucidum are presented with accompanying air studies. No previous report of such cases has been found in the American literature.
- (5) A procedure for distinguishing solid tumors from cysts is suggested, i.e. attempted puncture of the septum pellucidum by an exploring trocar.*

We wish to thank Dr. Bernard S. Brody, Associate Clinical Professor, Department of Neurosurgery and Dr. Allen I. Saunders for their aid in the study of Case 1.

* The publication of this paper has been financed in part by funds from The Connecticut Cancer Society. Dr. Robert Shapiro formerly resident in Radiology at the Grace Hospital is now Radiologist at the St. Raphaels Hospital, New Haven, Conn.

In addition, our appreciation is extended to Dr. Stanley Durlacher of the Department of Pathology of Yale University and to Dr. Abner Wolf for their review of the pathologic material.

Our thanks are extended to Dr. William Mendelsohn, Director of the Tumor Clinic of the Grace Unit.

We wish to thank Dr. A. P. Echternacht for permission to reproduce Figure 7 and Dr. S. J. Silverman for permission to reproduce Figure 6.

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REFERENCES

1. BACKMAN, G. Septum pellucidum and vergae ventricle. *Upsala läk. förhandl.*, 1924, 29, 225-240.
2. BAILEY, P., and CUSHING, HARVEY. Tumors of the Glioma Group. J. P. Lippincott Co., Philadelphia, 1926.
3. BERKOWITZ, N. J. Noncommunicating cyst of the septum pellucidum, with recovery following ventriculography. *Minnesota Med.*, 1939, 22, 402-405.
4. BUNTS, A. T., and CHAFFEE, J. S. Agenesis of corpus callosum with possible porencephaly; review of literature and report of case. *Arch. Neurol. & Psychiat.*, 1944, 51, 35-53.
5. BUSCH, E. New approach for removal of tumors of third ventricle. *Acta psychiat. et neurol.*, 1944, 19, 57-60.
6. CARDONA, F. Sui tumori del setto pellucido. *Riv. di pat. nerv.*, 1936, 47, 265-277.
7. CAUL, H., DOWLING, E., and KRAFF, E. E. Glioblastoma of septum pellucidum. *Semana méd.*, 1943, 2, 931-940.
8. DANDY, W. E. Diagnosis, localization and removal of tumors of the third ventricle. *Johns Hopkins Hosp. Bull.*, 1922, 33, 188-189.
9. DANDY, W. E. Congenital cerebral cysts of the cavum septi pellucidi (fifth ventricle) and cavum vergae (sixth ventricle); diagnosis and treatment. *Arch. Neurol. & Psychiat.*, 1931, 25, 44-66.
10. DANDY, W. E. Congenital cysts of the cavum septi pellucidi and cavum vergae. In: Lewis' Practice of Surgery. W. R. Prior Co., Inc., Hagenstown, Md., 1932, 12, 647-653.
11. DANDY, W. E. Benign Tumors in the Third Ventricle of the Brain: Diagnosis and Treatment. Charles C Thomas, Springfield, Ill., 1933.
12. DART, R. A. Genesis of the cavum septi pellucidi. *J. Anat.*, 1925, 59, 369-378.
13. DAVIDOFF, L. M., and DYKE, C. G. Agenesis of corpus callosum; its diagnosis by encephalography. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1934, 32, 1-10.
14. DAVIDOFF, L. M., and DYKE, C. G. Congenital tumors in the rostral portion of third ventricle; their diagnosis by encephalography. *Bull. Neurol. Inst. New York*, 1935, 4, 221-263.
15. DAVIDOFF, L. M., and DYKE, C. G. The Normal Encephalogram. Lea & Febiger, Philadelphia, 1937.
16. DYKE, C. G., and DAVIDOFF, L. M. Congenital absence of septum pellucidum; its diagnosis by encephalography. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1935, 34, 573-578.
17. DYKE, C. G., and DAVIDOFF, L. M. The Pneumoencephalographic Diagnosis of Tumors of the Corpus Callosum. *Bull. Neurol. Inst. New York*, 1936, 4, 602-623.
18. ECHTERNACHT, A. P., and CAMPBELL, J. A. Midline anomalies of the brain. *Radiology*, 1946, 46, 119-131.
19. EPSTEIN, B. S., and DAVIDOFF, L. M. Use of laminagraphy with encephalography in the diagnosis of midline and subtentorial brain tumors. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1946, 55, 675-688.
20. HYNDMAN, O. R., and PENFIELD, W. Agenesis of the corpus callosum; its recognition by ventriculography. *Arch. Neurol. & Psychiat.*, 1937, 37, 1251-1270.
21. LESLIE, W. Cyst of the cavum vergae. *Canad. M. A. J.*, 1940, 43, 433-435.
22. LIST, C. F., HOLT, J. F., and EVERETT, M. Lipoma of the corpus callosum; clinico-pathologic study. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1946, 55, 125-134.
23. LUTZ, W., and TURNER, O. Planigraphic studies of the ventricular system; fourth ventricle and adjacent structures. *Yale J. Biol. & Med.*, 1940, 12, 399-405.
24. LYSHOLM, E. Das Ventrikulogramm. I. Röntgentechnik. *Acta radiol.*, 1935, suppl. 24.
25. MARRAS, S. Sui gliomi del setto pellucido. *Riv. di pat. nerv.*, 1933, 42, 265-282.
26. PANCOAST, H. K., PENDERGRASS, E. P., and SCHAEFFER, J. P. The Head and Neck in Roentgen Diagnosis. Charles C Thomas, Springfield, Ill., 1940.
27. PENDERGRASS, E. P., and HODES, P. J. Dilatations of the cavum septi pellucidi and cavum vergae. *Ann. Surg.*, 1935, 101, 269-295.
28. PURVES-STEWART, JAMES. Intracranial Tumours and Some Errors in their Diagnosis. Oxford University Press, New York, 1927.
29. SALTYKOW, M. Glioma of the septum pellucidum. *Cor.-Bl. f. Schweiz. Aerzte*, 1911, 41, 674.
30. SCOTT, M. Cyst of the sixth ventricle (cavum of Verga); successful removal through trans-ventricular approach with notes on embryology and histopathology. *J. Neurosurg.*, 1945, 2, 191-201.
31. SILBERMAN, S. J. The so-called fifth and sixth ventricle. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1945, 54, 503-511.

32. SOSMAN, M. C. In discussion of paper by Echter-nacht and Campbell.¹⁸
33. SOUQUES, ALAJOURANIME, and BERTRAND, J. Primary tumor of the septum pellucidum with dementia. *Rev. neurol.*, 1922, 29, 270-274.
34. THOMPSON, I. M. On the cavum septi pellucidi. *J. Anat.*, 1932, 67, 59-77.
35. TURNER, O., and LUTZ, W. Planigraphic studies of the fourth ventricle; preliminary report with illustrative case. *Yale J. Biol. & Med.*, 1940, 12, 251-253.
36. TWINING, E. E. Radiology of third and fourth ventricles. *Brit. J. Radiol.*, 1939, 12, 385-418; 569-598.
37. URECHIA, C. I., and KERNBACH, M. Tumeur du septum lucidum, *Bull. et mém. Soc. méd. de hôp. de Paris*, 1929, 53, 1055.
38. VAN WAGENEN, W. P., and AIRD, R. B. Dilatations of cavity of septum pellucidum and cavum vergae. *Am. J. Cancer*, 1934, 20, 539-557.
39. WOLF, A., and BAMFORD, T. E. Cavum septi pellucidi and cavum vergae. *Bull. Neurol. Inst. New York*, 1935, 4, 294-309.
40. WOLF, E. Glioma of the septum pellucidum with extension into the corpus callosum. *Centralbl. f. allg. Path. u. path. Anat.*, 1921, 31, 257-265.
41. YOUNG, A. W. Comparative anatomy of septum pellucidum. *Psychiat. en Neurol. Bl. Amst.*, 1926, 30, 203-234.
42. ZIMMERMAN, H. M., and GERMAN, W. J. Colloid tumors of third ventricle. *Arch. Neurol. & Psychiat.*, 1933, 30, 309-325.



VISUALIZATION OF THE ROKITANSKY-ASCHOFF SINUSES OF THE GALLBLADDER DURING CHOLECYSTOGRAPHY

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A SEARCH of the literature revealed no record of the demonstration of Rokitsky-Aschoff sinuses during cholecystography, and since it produces a unique appearance that seems to be characteristic, a case demonstrating this phenomenon is being reported together with a discussion of the condition. Of secondary interest in this case is the occurrence of a double gallbladder shadow produced by a stricture of the gallbladder.

CASE REPORT

A white female, Mrs. J. B., aged twenty-seven, was referred for an intravenous urogram because of pain in the right side. This study revealed a marked hypogenesis of the right kidney with compensatory hypertrophy of the left kidney. It was then felt that the patient's symptoms might be biliary in origin, and a cholecystogram was made. This revealed a double gallbladder shadow of a slightly less than normal degree of density. An unusual narrow concentric shadow of dye was noted around one of the gallbladder shadows. The examination was repeated with 9 grams of priodax in an attempt to get as dense a gallbladder shadow as possible in order to try to visualize an accessory cystic duct or a communication between the two pouches, and the result is shown in Figure 1. Various projections were employed, including the erect (Fig. 2) and a very marked Trendelenburg, but no communication between the two pouches could be demonstrated. The dye in the lower pouch was somewhat more concentrated than that in the upper one. After a fat meal, both pouches contracted, the upper one more than the lower. There was no evidence of calculi. The reason for this report, however, is the peculiar rim of dye passing in a layer concentrically around the surface of the lower pouch, as seen in Figures 1, 2, 3, 4 and 5. This finding was constant and was seen in each of three cholecystographic examinations done on this patient. The concentric ring is more ap-

parent when the gallbladder is contracted after a fat meal. Calcification in the wall of the gallbladder was not a factor here since no shadow was seen on the preliminary plain film. No adequate explanation could be given for it, and the situation was confused by the fact that we were trying to demonstrate an accessory duct in an attempt to prove the presence of a true double gallbladder.

Cholecystectomy was performed and a pe-



FIG. 1. The double shadow of the gallbladder is well seen, as is also the very small hypoplastic kidney. Note the fine white line on both sides of the lower gallbladder shadow, especially well seen on the lateral aspect.



FIG. 2. Examination in the erect posture shows no communication between the two pouches, but again demonstrates the dye in the Rokitansky-Aschoff sinuses around the lower pouch and at the constricted waist of the gallbladder.

4 cm.). At the upper end of the cavity, the lumen narrowed abruptly to a filiform size due to a narrow constriction, after which it again became widened into a small sac about 2 cm. in diameter, the walls of which were thin and had



FIG. 4. Another view after the fat meal from a slightly different projection, showing further contraction of the upper pouch and very good visualization of the Rokitansky-Aschoff sinuses in the mid-portion of the gallbladder in the region of the stricture.

the appearance of a relatively normal gallbladder. This second sac then emptied into a short cystic duct, which entered a somewhat dilated common duct in the usual fashion. Only

FIG. 3. After a fat meal, there is demonstrated good contraction of the upper pouch, and the short cystic and the common duct are visualized. The Rokitansky-Aschoff sinuses around the lower pouch are much better visualized at this time since the intracystic pressure is increased.

culiar gallbladder was encountered that contained no gallstones. The lower two-thirds of the organ had a uniformly greatly thickened wall measuring 1.5 cm. in thickness, and the cavity corresponded approximately in size to the lower shadow seen on the cholecystogram (about 2 by



one cystic duct was found and the gallbladder was apparently a single one with a narrow constriction dividing it into two segments (Fig. 6). The thickened lower portion of the gallbladder was rubbery in consistency, and considerable subserosal fat was evident. Just below the mucosal surface, there was a bile-stained thin layer running parallel to the surface in which a few tiny cystic spaces, about 1 mm. in diameter,



FIG. 5. Another cholecystogram on this patient shows both pouches more equally contracted and again demonstrates the dye in the Rokitansky-Aschoff sinuses.

were seen. This layer corresponded exactly to the one visualized in the cholecystogram.

Microscopic sections (Fig. 7 to 10) showed that the mucous membrane still looked relatively normal. Projecting downward from the surface epithelium were long crypts which passed through the subepithelial and muscle layers and formed tiny cystic spaces and duct-like ramifications in the connective tissue just external to the muscle layer. It seems inescapable that the presence of cholecystographic dye in these structures is what gave the peculiar extra shadow around the lumen of the gallbladder. The better visualization of this concentric ring when the gallbladder was con-

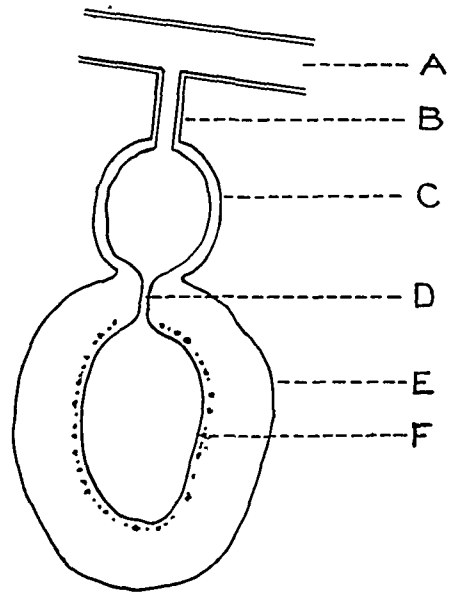


FIG. 6. A schematic drawing in longitudinal section of the operative and gross pathological findings. *A*, common duct; *B*, cystic duct; *C*, upper pouch of gallbladder; *D*, stricture of gallbladder; *E*, greatly thickened lower pouch of gallbladder; *F*, bile stained row of Rokitansky-Aschoff sinuses.

tracted is what one would expect with herniations of the mucosa through the muscularis.

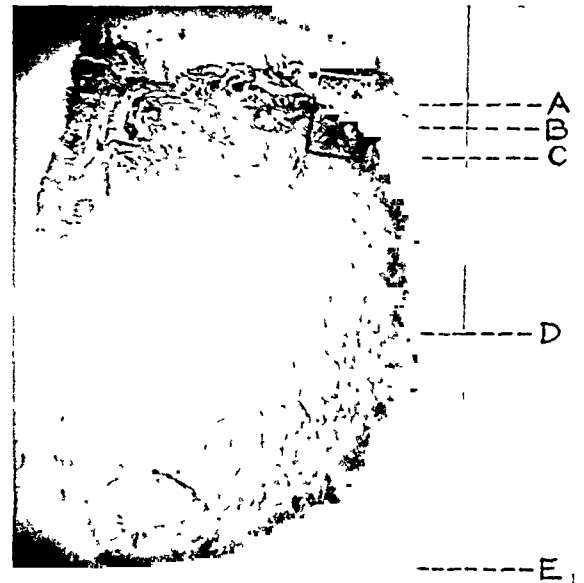


FIG. 7. Low power (5X) of microscopic section of wall of lower pouch of gallbladder. *A*, mucosa; *B*, muscular layer (small, dark bundles); *C*, Rokitansky-Aschoff sinuses in perimuscularis; *D*, greatly thickened perimuscularis; *E*, serosa.

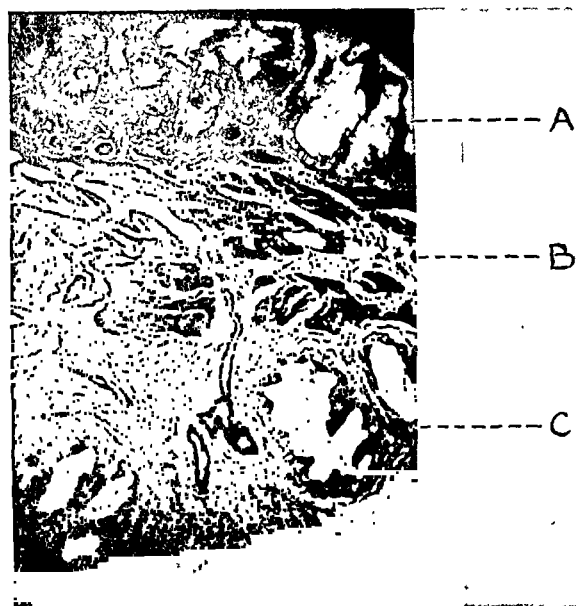


FIG. 8. Low power (60X) photomicrograph of the small rectangular segment marked in Figure 7.

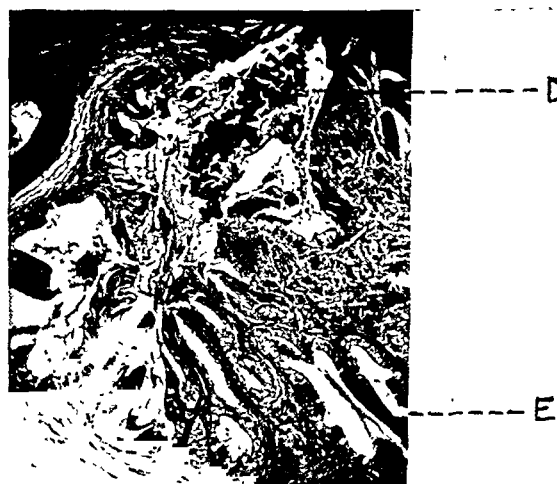
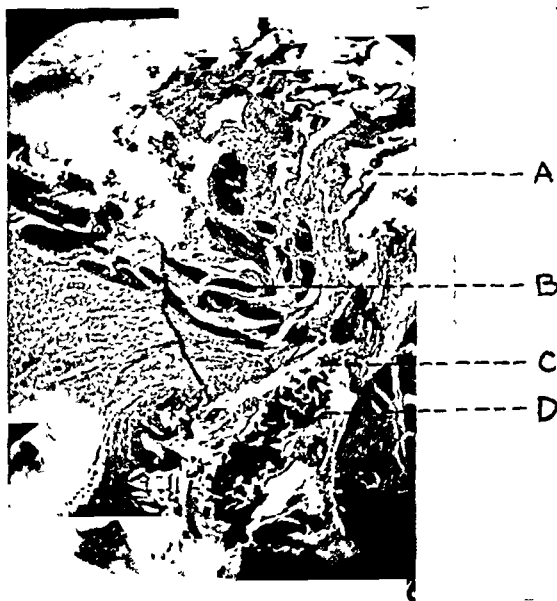


FIG. 9. Low power (60X) photomicrograph showing the actual penetration of the muscular layer by a branching Rokitansky-Aschoff sinus. The black granular material in the lumen is a clump of cholesterolin crystals. The lower photomicrograph is a continuation of the upper since the entire sinus could not be included in a single field. *A*, mucosa; *B*, muscular layer; *C*, penetration of muscular layer by Rokitansky-Aschoff sinus; *D*, cholesterolin crystals; *E*, terminal ramifications of the sinus in the perimuscularis.



FIG. 10. This shows the branching sinuses in the perimuscularis. The muscle layer is above the field included in this view.

The major portion of the increased thickness of the gallbladder was due to a marked thickening of the fibrous tissue layer between the thin muscular coat and the serosal surface. Numerous fat cells were present in this proliferated connective tissue matrix, and a few small foci of lymphocyte aggregations were present.

DISCUSSION

In a series of studies dealing with the morphology of the gallbladder, Halpert^{2,3} clearly distinguishes the so-called "Rokitansky-Aschoff sinuses" from what he calls the "true Luschka ducts" as found in the gallbladder, and he calls attention to some historical confusion in the naming and recognition of these structures. Rokitansky in 1842 called attention to "hernia-like outpouchings of the gallbladder mucosa" toward the external layers of the gallbladder, and Aschoff in 1905 first described them in terms of modern histology, calling them "Luschka's ducts" and emphasizing their pathological significance especially in connection with biliary stasis in the gallbladder and with the formation of gallstones. It was soon pointed out that these structures were not the aberrant bile ducts discovered by Luschka in 1863 in the wall of the gallbladder.

According to Halpert, the normal human gallbladder has four layers: (1) the mucosa; (2) the muscularis; (3) the perimuscularis; and (4) the serosa. The mucosa consists of a single row of uniform columnar epithelium. It is thrown into very small folds that give a fine reticulated effect to the surface. The epithelium rests on a very thin layer of connective tissue called the subepithelium, which accommodates the rich capillary plexus of the mucosa. The human gallbladder has no submucosa. The muscularis is a very thin web of longitudinal, oblique and circular delicate muscle bundles, with a small amount of cellular connective tissue between them. The perimuscularis is a layer of connective tissue around the muscularis. It is denser just beneath the muscularis, and is looser, less cellular and contains some fat cells in the subserous portion.

The serosa is found only on the peritoneal aspect of the viscus.

The healthy human gallbladder rarely shows the presence of Rokitansky-Aschoff sinuses.² If present at all, they are shallow. The name is applied to the deeper outpouchings or sinuses of the gallbladder mucosa which dip down into the muscularis or extend as finger-like processes through the muscular coat into the perimuscular layer.³ It is thought that these are not proliferations, but are herniations into and through the interstices and delicate septa between the muscle bundles. Halpert feels that the muscularis of the healthy gallbladder under ordinary conditions is dense enough to prevent such outpouchings. When the gallbladder is pathologically involved, there occurs in it a more or less general loosening and weakening of the contractile elements with a widening of the intermuscular septa, under which circumstances extreme contractions which follow prolonged and repeated overdistentions of the viscus are most likely to play the leading part in the production of these herniations. The length, diameter and manner of penetration of the Rokitansky-Aschoff sinuses show infinite variations. The most distal portion or fundus may show a wider lumen if it penetrates into the perimuscularis, the narrower neck causing it to resemble a round-bottomed flask.

True Luschka ducts are fine duct-like structures lined with cuboidal epithelium and with lumina generally less than 0.3 mm. in diameter, that are found occasionally in the outermost layers of the gallbladder wall, usually on the hepatic surface of the viscus. They have a fibrous wall of their own with the histologic structure of intrahepatic bile ducts. They never communicate with the lumen of the gallbladder.

The gallbladders which show Rokitansky-Aschoff sinuses are usually thickened, owing to an infiltration of inflammatory cells in the subepithelial layer and the perimuscularis as well as connective tissue proliferation and some edema; in other words, evidence of chronic cholecystitis.

They may be found associated with gallstones. Sometimes, these crypts or sinuses undergo cystic dilatation, producing small macroscopically visible cysts, and the condition is then designated as chronic cystic cholecystitis.

In 1931, King and MacCallum⁵ described a condition which they called cholecystitis glandularis proliferans, in which there was a marked localized or diffuse thickening of the gallbladder. The outstanding feature of the thickened area was a marked downgrowth of the epithelium through the subepithelial and muscular layers, invading the greatly thickened subperitoneal layer. The authors regard the process as a definite proliferation. They make no mention of any resemblance or possible relationship to Rokitsky-Aschoff sinuses. The fact that many of their cases showed only localized involvement with nodule formation would indicate that the process they were describing was not a phenomenon of evagination, but was actually a proliferative one. Nevertheless, the microscopic sections of both conditions show considerable resemblance, unless there is also a proliferation of smooth muscle elements around the crypts, in which case the condition would resemble a so-called "adenomyoma." These epithelial crypts were entirely orderly in arrangement and the cells were benign in appearance. When the condition was localized, the thickened nodule might project from either the mucosal (and would then be regarded as a papilloma) or the serosal surface. Some of their cases showed small macroscopic cysts, and then they were indistinguishable from cholecystitis cystica. The marked thickening of the involved areas was due in large part to extensive proliferation of connective tissue cells and to deposits of fat intermingled with the connective tissue. Collections of small round cells were also encountered. Many of these cases grossly were thought to be carcinoma of the gallbladder because of the marked thickening of the wall. Two of the latter were originally considered malignant even microscopically, but the subsequent benign clinical course

made this diagnosis untenable. The patients all had signs and symptoms of chronic cholecystitis. The vast majority had gallstones at operation, and more than one-third had an acute inflammatory process superimposed. The condition was found in 9.5 per cent of 400 gallbladders, but the cases were somewhat selected, since a number were referred to the authors because of their interest in the condition. King and MacCallum make no mention of the results of cholecystography in this condition. They felt that the condition had been described previously many times under a variety of names: adenoma, polyp, cystadenoma, fibro-adenoma, adenomyoma, etc.

In the case being reported in this paper, it was felt that the stenotic stricture in the gallbladder was congenital, both from the nature of the abnormality, the relative youthfulness of the patient and the presence of a second congenital abnormality, a marked hypoplasia of the right kidney with the characteristic bud-like pelvis. The markedly thickened lower sac of the gallbladder apparently represents a chronic cholecystitis showing marked Rokitsky-Aschoff sinuses. The microscopic picture would also fit into the description of cholecystitis glandularis proliferans, and Halpert⁴ finds it difficult to distinguish the two, and does not feel that the latter is a clearly defined entity, but rather a confusion of cases of chronic cholecystitis showing Rokitsky-Aschoff sinuses with cases of adenomyoma that may or may not be accompanied by chronic cholecystitis. It is impossible to tell whether absorptive and concentrating power was present in both sacs, or in the upper sac alone, in which event the concentrated dye may have merely settled into the lower sac by gravity. The fact, however, that the lower sac demonstrated good contractile power suggests that it probably also had concentrating function.

SUMMARY

1. Rokitsky-Aschoff sinuses of the gallbladder are discussed.

2. The confusing similarity of some cases of cholecystitis glandularis proliferans to Rokitansky-Aschoff sinuses is brought out.

3. When Rokitansky-Aschoff sinuses are visualized during cholecystography, a unique picture is produced, which seems to be characteristic.

4. Visualization is rare probably because gallbladders showing Rokitansky-Aschoff sinuses are diseased, and concentration is probably usually considerably impaired.

5. A case is reported in which visualization of Rokitansky-Aschoff sinuses during cholecystography occurred.

6. Of secondary interest in this case is a double gallbladder shadow produced by a stricture in the body of the gallbladder.

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REFERENCES

1. BOYD, WILLIAM. A Text-Book of Pathology. Third edition. Lea & Febiger, Philadelphia, 1938.
2. HALPERT, B. Morphological studies on the gallbladder. I. A note on development and microscopic structure of normal human gall-bladder. *Bull. Johns Hopkins Hosp.*, 1927, 40, 390-408.
3. HALPERT, B. Morphological studies on the gallbladder. II. The "true Luschka ducts" and "Rokitansky-Aschoff sinuses" of human gallbladder. *Bull. Johns Hopkins Hosp.*, 1927, 41, 77-103.
4. HALPERT, B. Personal communication, Nov. 19, 1945.
5. KING, E. S. J., and MACCALLUM, P. Cholecystitis glandularis proliferans (cystica). *Brit. J. Surg.*, 1931, 19, 310-323.
6. WALTERS, W., and SNELL, A. M. Diseases of the Gallbladder and Bile Ducts. W. B. Saunders Co., Philadelphia, 1940.
7. WEISS, SAMUEL. Diseases of the Liver, Gall Bladder, Ducts and Pancreas. Paul B. Hoeber, Inc., New York, 1935.



MYOSITIS OSSIFICANS PROGRESSIVA IN HOMOZYGOTIC TWINS*

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WE HAVE had the opportunity of studying homozygotic twins in both of whom the rare condition, myositis ossificans progressiva, was present. These two cases are being presented because the condition has not been reported, previously, as occurring in twins. The occurrence of myositis ossificans progressiva in identical twins, although it does not definitely establish the fact, strongly suggests that the etiological factor in this disease is a genetic one.

MYOSITIS OSSIFICANS PROGRESSIVA

"Myositis ossificans progressiva" is a misnomer in that the pathologic condition which bears this name is neither a myositis nor an ossification of muscles. On the contrary, there is an ossification of the connective tissue about the muscles. This connective tissue is frequently attached to the bones or forms an articulation with the bone. Mair has suggested the more appropriate name of "fibrositis ossificans progressiva." There is usually an associated characteristic deformity of the metatarsals, metacarpals and phalanges, particularly of the great toes and thumbs, which resembles hereditary deforming osteochondrodystrophy.

A case of myositis ossificans was first described and recorded in the literature by Guy Patin in 1692. It was given its present name of myositis ossificans progressiva by von Dusch in 1868. Numerous cases have been reported since that time.

DISCUSSION

Many normal variants as well as many pathological conditions are gradually being established as inheritable entities. This

presentation is not concerned with the numerous abnormalities of the nervous system, the hematopoietic system or the viscera in which heredity is justly presumed, or has been definitely proved to be an etiological factor. We are not particularly concerned with inheritable abnormalities of the muscles since myositis ossificans progressiva, as has already been pointed out, is really not a condition which is primary in the muscles but is rather an ossification of the connective tissues.

There are numerous abnormalities of the skeleton and adjoining soft tissues in which heredity has been definitely proved, i.e.,

Brachydactyly—middle phalanx short or fused to terminal phalanx.

Minor brachydactyly.

Polydactyly.

Arachnodactyly—unusually long bones associated with other somatic defects.

Absence of patella.

Syndactyly—web fingers.

Osteochondrodystrophies—achondroplasia, multiple exostoses, enchondromas, chondromas, chondrodysplasia, lipochondrodystrophy (gargoylism).

Sclerosing osteopathies—osteopoikilosis, osteopetrosis, melorheostosis.

Osteogenesis imperfecta (certain types).

Osteitis deformans (possible hereditary factor).

Myositis ossificans progressiva is an abnormality characterized by skeletal anomalies, as illustrated elsewhere, and by the ossification of the connective tissues adjoining the bones. We believe this condition should be added to the above list of inheritable conditions. The presumptive evidence upon which this contention is based is the occurrence of this abnormality

* Presented before the Second Inter-American Congress of Radiology, Havana, Cuba, Nov. 17-22, 1946.

(with similar-appearing lesions) in homozygotic twins.

Other observers have recognized the possibility that myositis ossificans progressiva is an inherited condition. We believe that we have brought forth evidence to further substantiate this impression.

ETIOLOGY

The etiology of myositis ossificans progressiva is unknown. There have been numerous theories propounded regarding its cause. These will not be elaborated upon or even reviewed since we believe there is now sufficient evidence to establish the most probable cause as being an hereditary one. This impression has been based on the following evidence:

1. The occurrence of myositis ossificans progressiva in monozygotic twins (as reported in this presentation).
2. The occurrence of this rare condition in father and son as reported by Burton-Fanning and Vaughn. Gaster also reported the disease in a father and grandfather, as well as in three sons, all in the same family.

Uehlinger stated that the disease is probably hereditary. He also stated that, etiologically, the traumatic, inflammatory, trophoneurotic and blastomatous theories could be rejected, that the disease was a true mutation of the mesenchyma.

3. The frequent association of deformities of the extremities in myositis ossificans progressiva which roentgenologically resemble osteochondrodystrophy, a recognized hereditary condition.

In a personal communication, Dr. R. R. Spencer, Director of the National Cancer Institute at Bethesda, Maryland, states:

The fact that the disease [myositis ossificans progressiva] occurred in monozygotic twins does not establish it as genetic, for there are many factors other than genes that identical twins have in common.

The occurrence in monozygotic twins does, however, suggest genetic influence, but the

critical test is the comparison of a series of cases in monozygotic twins with another series of cases in dizygotic twins. Owing to the rarity of the disorder it is doubtful that such a comparison can ever be made.

CLINICAL MANIFESTATIONS

The condition is more frequent in males although it may occur in either sex.

It is first manifested in infancy or early childhood by a soft tissue swelling, usually beginning in the cervical or upper dorsal region. This is painful and tender. Redness and heat may be present, suggesting an acute process. The soft tissue swelling may spontaneously disappear or it may lose its acute manifestations, a firm mass remaining. Opacity due to ossification in this mass may be demonstrated roentgenologically. There is a progressive stiffness and limitation of motion of the neck, chest, back and later the extremities, particularly the shoulders. The dorsal aspect of the trunk is more frequently affected than the ventral aspect, and the upper half of the body more frequently than the lower half. The lower extremities are rarely affected.

Invalidism gradually develops with a resulting atrophy of disuse of the muscles. The patient becomes thin and weak.

The process is spontaneously arrested early in the third decade of life. Apparently it is related to the period of physiologic growth. The cases usually terminate fatally in the third or fourth decade due to intercurrent infections. The respiratory embarrassment is probably a contributing factor to the intercurrent infection.

There are usually associated congenital anomalies of the thumbs and great toes. The appearance is that of a microdactylia and it is due to absence or shortening of some of the phalanges and, frequently, fusion of the phalanges. There are also deformities of the proximal ends of the phalanges and distal ends of the metatarsals.

ROENTGENOLOGICAL MANIFESTATIONS

There is progressive ossification of muscle

sheaths, tendons, and intervening connective tissue.

Irregular bands of ossification are found in various portions of the body. The cervical region, particularly the sternocleidomastoid area is usually involved. The ribs and scapular areas, especially the connective tissues about the axillary muscles, are often affected. The ligaments of the spine usually contain extensive ossifica-

joints of both great toes (this resembles hereditary osteochondrodystrophy). The phalanges of the toes, particularly the great toes, and the fingers, especially the thumbs, are frequently fused and maldeveloped, resulting in microdactylia.

PATHOLOGY

Microscopic examination of a mass of bony structure from soft tissues of the back



FIG. 1 Identical twins, C. M. and M. M. Note identical appearance, similar eyes, hair and features. The osseous structures and blood types are identical.

tion. Ossification is present about the pelvis, particularly in the region of the hip joints and about the muscles of the thighs.

False joints (synostoses) may be formed with the ribs, spine, shoulder girdles, or about the hips. The osseous bands may result in bony ankylosis.

There is apicocaudal progression of the disease. Scoliosis is frequent. There is deformity of the thorax due to fixation of the ribs. Exostoses may project from the cortices of the long bones of the extremities. There is hallux valgus due to defective ossification about the metatarsophalangeal

in one of our cases was reported as quite normal bone. The microscopic findings reported by various observers are almost as varied as the number of pathologists reporting. This wide variety of descriptions is probably due to a different stage of the disease existing at the time the particular examination was made.

CASE HISTORIES OF THE TWINS M. M. AND C. M. (FIG. 1)

M. M. was first seen in the clinic of the Woman's College Hospital in November, 1933, at the age of ten years. The chief complaint

was "stiff neck." It was also noted at that time that there was "soreness in the joints." The referring physician had advised admission for tonsillectomy and adenoidectomy since the patient was said to have had "attacks of arthritis" for three months. Accordingly the child was admitted to the hospital in January, 1934, at which time a tonsillectomy and adenoidectomy were performed. In the history, it was noted that there was constant stiffness in the region of the cervical vertebrae.

Past medical history included pneumonia,

Past medical history included only measles at six years.

Physical examination noted a thin, pale child of eleven years of age. The neck was stiff and the anterior cervical glands were enlarged. The back was stiff and there was a curvature to the left in the lumbar region. Bony sharp prominences were noted protruding from below the angles of the scapulae. The patient was unable to raise her arms to a right angle. The left phalangeometatarsal joint was enlarged and stiff and the left great toe was short.



FIG. 2. Posterior view of twins. Deformity of back due to ossification in the soft tissues.

mastoiditis and measles before three years of age. A mastoidectomy had been performed when the child was two years old.

Physical examination included the observation that the patient had a fixed stare and that there was spasticity of all the extremities and the vertebrae. The fingers were held in a position of extension and the child held the right hand with the left. She could not sit upright but had to be propped up.

C. M. was referred for tonsillectomy and adenoidectomy to the same hospital in May, 1934, for "arthritis of the cervical vertebrae since July, 1930." There was a history of numerous colds with frequent swelling of the cervical glands.

Birth and Family History of M. M. and C. M. Delivery normal. Both children weighed between 3 and 4 pounds at birth. They sat up at approximately eight months and walked at about eighteen months of age. Four brothers living and well; three sisters living and well. No siblings dead; no miscarriages.

No family history of any mental disease, congenital anomalies or diseases similar to this one. Maternal grandparents died in their eighties and paternal grandparents were both in their late seventies at the time of their deaths.

COMPARISON OF ROENTGENOLOGIC PICTURE AND FOLLOW-UP ON TWINS

Five years after the hospital admission of the second twin (C. M.) both girls were

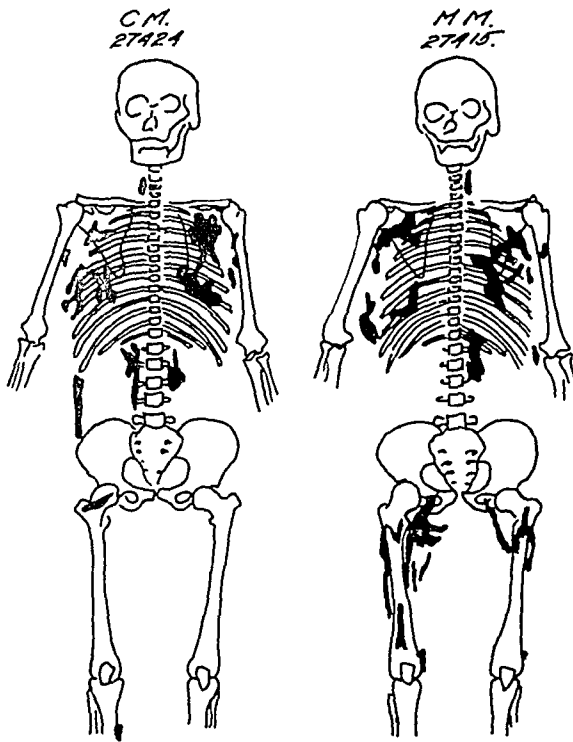


FIG. 3. Chart showing distribution of ossification the soft tissues (myositis ossificans progressiva).

referred to the department of radiology for study. The results of the roentgenographic examination are recorded schematically in Figure 3. In both there was ossification posteriorly in the cervical region (Fig. 4). From the histories it seems obvious that



FIG. 5. Roentgenogram of M. M. demonstrating ossification of the soft tissues of the back.

the disease in these cases, as in the typical cases recorded in the literature, became manifest first in the connective tissues lying in relation to the cervical muscles. In both girls abnormal ossification was seen to be most extensive in the subcutaneous tissues of the back (Fig. 2 and 5). M. M. showed much more extensive ossification about the

FIG. 4. Roentgenogram of the cervical region. There is ossification in the soft tissues posteriorly. The disease is usually first manifested in this region. Note anomalies of the cervical spine (Klippel-Feil syndrome).



FIG. 6. Right thoraces and shoulders of identical twins, C.M., and M. M. Note similarity of skeletal structures roughly similar patterns of ossification in the soft tissues.

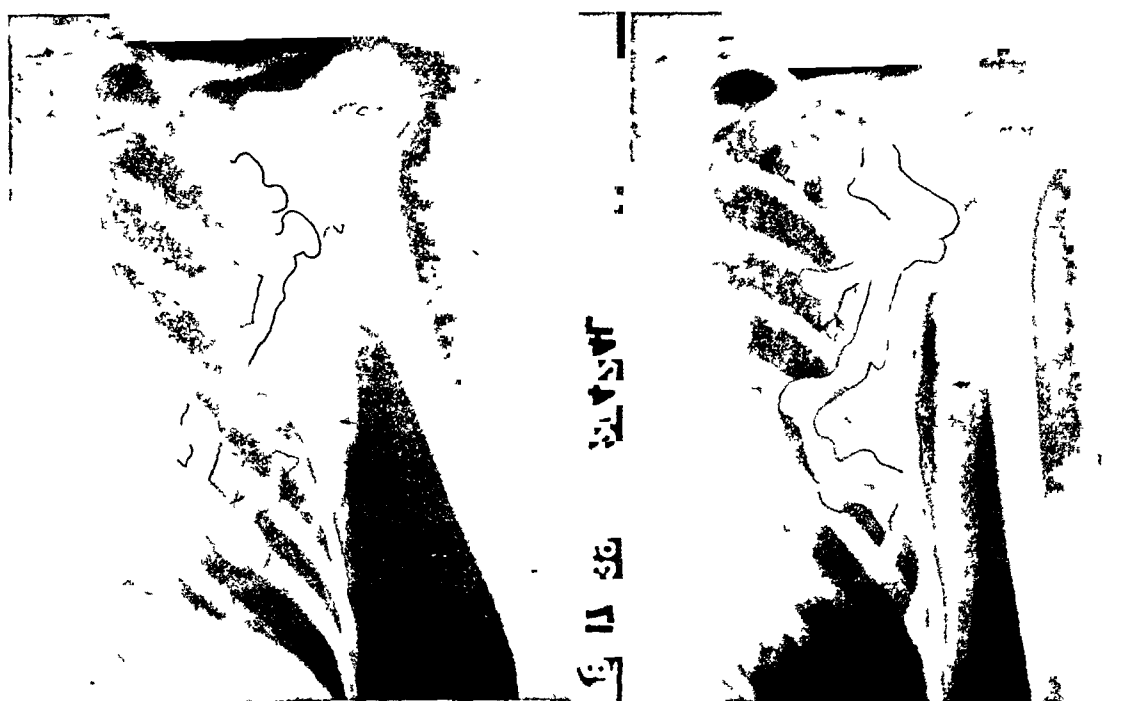


FIG. 7. Left thoraces and shoulders of identical twins, C. M., and M. M.

hip joints and upper femora than did C. M. (Fig. 8). In fact, for the past three years, M. M. has been unable to walk because of the immobility and fixation of the hip joints which has resulted from the abnormal deposition of bone in these areas. C. M. is still ambulant. As seen in Figure 8, there is deformity of the neck of the femur in C. M.



- this may be altered by training).
- (3) Eyes—the same color and pattern.
 - (4) Hair—the same color, form, and the same whorl.*
 - (5) Finger prints and foot prints—the same general patterns although not identical finger prints.
 - (6) Identical skeletal development* and



FIG. 8. Left hips of C. M. and M. M. There is deformity of the neck of the femur in C. M. resembling that seen in hereditary deforming osteochondrodystrophy. There is extensive ossification of the soft tissues in M. M.

which resembles that seen in hereditary deforming osteochondrodystrophy. Figure 9 shows fusion of the phalanges in the great toes of both patients. There is hallux valgus with deformities of the distal ends of the first metatarsal bones

CRITERIA FOR ESTABLISHING THE IDENTITY OF HOMOZYGOTIC TWINS

Identical (homozygotic) twins are the product of one fertilized egg which has divided. The two halves of this egg, barring deformities or changes incident to environment or acquired diseases, must be identical. The criteria, now established, for identifying twins include:

- (1) Blood group—the same.
- (2) Handedness—the same (although

patterns of ossification† of the costal cartilages as demonstrated on roentgenograms.

The twins, M. M. and C. M., fulfill these criteria. Their blood type is B and they are both Rh positive. Figure 6, showing the right thoraces and shoulders of the twins, demonstrates the similarity of the skeletal structures. A roughly similar pattern of ossification is demonstrable in the soft tissues.

* The handedness, hair whorls, and skeletal structures are the same in homozygotic twins except in cases of reverse or mirror-imaging in which cases these characteristics are reversed.

† The authors, in another paper in this issue of the JOURNAL, discuss their reasons for including this among the criteria for establishing the identity of homozygotic twins. (This publication is entitled "Genetic Influence on Osseous Development with Particular Reference to the Deposition of Calcium in the Costal Cartilages.")

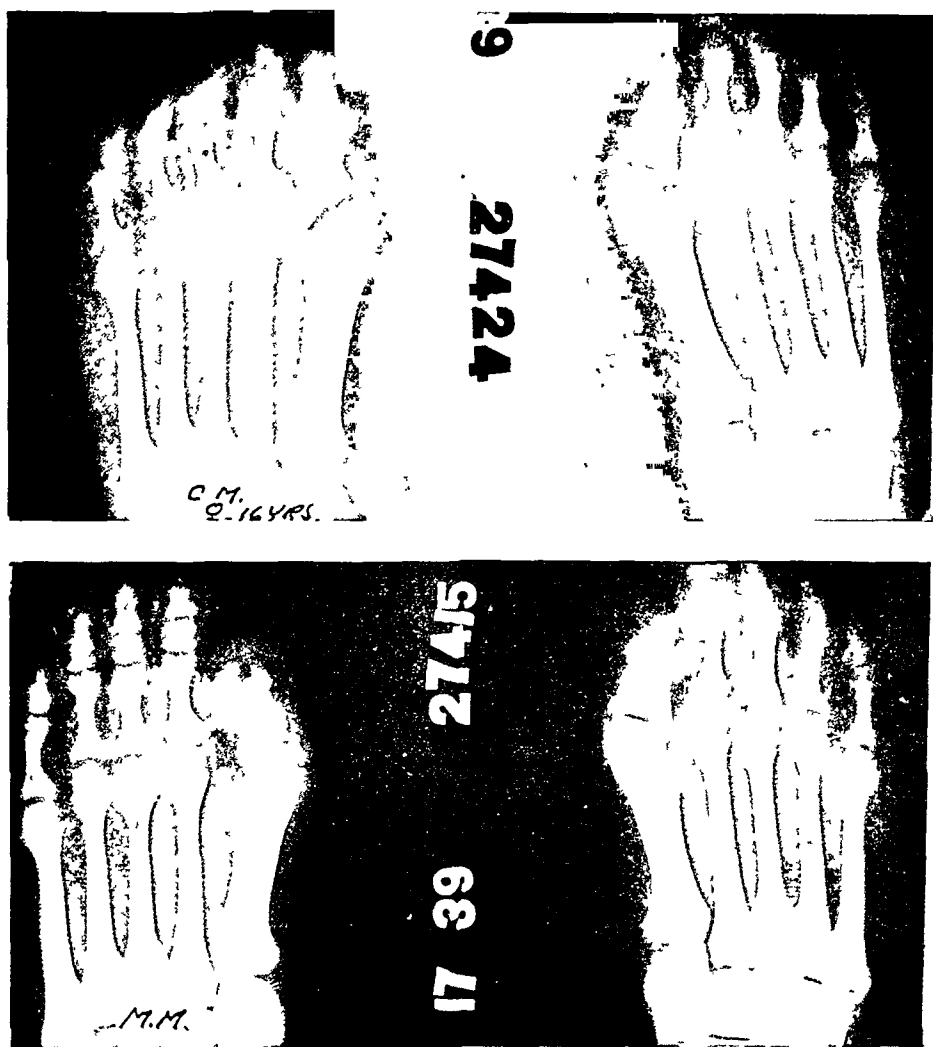


FIG. 9. Roentgenograms demonstrating similar deformities of the feet of the identical twins, C. M. and M. M. These changes consist of deformities of the great toes of both feet of both twins with fusion of the phalanges, hallux valgus and deformities of the distal end of the first metatarsals. Similar changes are also usually observed in the hands. They are quite characteristic of myositis ossificans progressiva and closely resemble the changes seen in hereditary deforming osteochondrodystrophy.

SUMMARY AND CONCLUSIONS

1. Myositis ossificans progressiva is a pathologic condition characterized by ossification of the connective tissues about the muscles.

2. The authors have observed the condition in identical twins.

3. Hitherto, the etiology of myositis ossificans progressiva has been questionable.

4. It is believed that its occurrence in homozygotic twins indicates that myositis

ossificans progressiva is genetic in origin.

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REFERENCES

1. CHAUDHURI, K. C. Myositis ossificans progressiva. *Indian J. Pediat.*, 1937, 4, 148-149.
2. DOBRZANIECKI, W. Problem of myositis ossificans progressiva. *Ann. Surg.*, 1936, 104, 987-992.
3. FREJKA, B. Heterotopic ossification and myositis

- ossificans progressiva, *St. Barth. Hosp. Rep.*, 1908, 43, 43-49.
4. GARROD, A. Diathesis. *Lancet*, 1927, 2, 1113-1118.
 5. GESCHICKTER, C. F., and MASERITZ, I. H. Myositis ossificans. *J. Bone & Joint Surg.*, 1938, 20, 661-674.
 6. HAMADA, G. Myositis ossificans multiplex. *Brit. M. J.*, 1936, 1, 840.
 7. MACKINNON, A. P. Progressive myositis ossificans. *J. Bone & Joint Surg.*, 1924, 6, 336-343.
 8. MAGRUDER, L. F. Myositis ossificans progressiva. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1926, 15, 328-331.
 9. MAIR, W. F. Myositis ossificans progressiva. *Edinburgh M. J.*, 1932, 39, 13; 69.
 10. NEWMAN, H. H., FREEMAN, F. N., and HOLZINGER, K. J. Twins: A Study of heredity and Environment. University of Chicago Press, Chicago, 1937.
 11. NUTT, J. J. Myositis ossificans progressiva. *J. Bone & Joint Surg.*, 1923, 5, 334-359.
 12. PACK, G. T., and BRAUND, R. R. Development of sarcoma in myositis ossificans. *J.A.M.A.*, 1942, 119, 776-779.
 13. PIRIE, G. S. Myositis ossificans progressiva. *Arch. Roentg. Ray*, 1910-1911, 15, 212-217.
 - 13a. RIGLER, L. G. Roentgen studies of twins and triplets. *Radiology*, 1938, 30, 461-470.
 14. ROSENSTERN, J. Contribution to study of myositis ossificans progressiva. *Ann. Surg.*, 1918, 68, 485; 951.
 15. SNOKE, P. O. Myositis ossificans progressiva; clinical notes and roentgen findings of new case. *Am. J. Surg.*, 1933, 21, 111-115.
 16. TUTUNJIAN, K. H., and KEGERREIS, R. Myositis ossificans progressiva, with report of case. *J. Bone & Joint Surg.*, 1937, 19, 503-510.
 17. VAN CREVELD, S., and SOETERS, J. M. Myositis ossificans progressiva. *Am. J. Dis. Child.*, 1941, 62, 1000-1013.



GENETIC INFLUENCE ON OSSEOUS DEVELOPMENT WITH PARTICULAR REFERENCE TO THE DEPOSITION OF CALCIUM IN THE COSTAL CARTILAGES*

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THE influence of heredity as an all important factor in the acquisition of many abnormalities of the skeletal system and adjoining soft tissues is well known. It is not so well known that the ossification which occurs normally in the costal cartilages is hereditarily determined. That this is true seems to have been proved by the occurrence of similar ossification patterns in the corresponding costal cartilages of identical twins.

HEREDITY

A brief discussion of the fundamental concepts of heredity may help to clarify the data and conclusions which are to follow.

The male reproductive cell (spermatozoon) containing twenty-four chromosomes combines with a female reproductive cell (ovum) containing twenty-four chromosomes. The chromosomes are the dark staining microscopic material in the nucleus of the cells. These chromosomes have a definite size and shape. The chromosomes are made up of smaller definite entities which are called *genes*. To these genes are attributed the hereditary determiners which establish the exact arrangement of the somatic cells of the new organism.

The somatic cells of the body all contain two sets of twenty-four chromosomes each or forty-eight. Half of these are derived from the sperm and half from the ovum. The characteristics of the body depend on the hereditary characteristics transmitted through the genes making up the chromosomes. When the sperm and ovum, each

containing twenty-four chromosomes, unite there results a fertilized ovum (zygote) containing forty-eight chromosomes or body determiners. These determine to the minutest detail how the body or somatic cells will look and how they will act. This means not only the appearance of the features and habitus but the roentgenological appearance of the finest details of the arrangement of the somatic cells (particularly of the osseous structures with which we are chiefly concerned in this presentation).

If, shortly after it begins to grow, a fertilized egg (zygote) splits in half to form two individuals, each will have exactly the same hereditary factors and *identical twins* will be the result. Since they are derived from the same fertilized egg (zygote) they are called *homozygotic* twins. If the division takes place after the embryo has begun to differentiate, the twins are opposite each other. Thus the right side of one homozygotic twin corresponds to the left side of the other twin. This is known as *reversal* or *mirror-imaging*. One twin is usually right handed, the other is left handed. The hair whorls are in opposite directions. The pattern of ossification of one side corresponds to the opposite side in the other twin.

The offspring contains the characteristics transmitted through the genes of the two parents and these go on through succeeding generations unchanged except for mutations. Mutations are alterations of the genes by factors which are poorly understood. Cosmic rays have been sug-

* Presented before the Second Inter-American Congress of Radiology, Havana, Cuba, Nov. 17-22, 1946.



FIG. 1. Identical twins A. B. and J. B., aged sixty-two years.

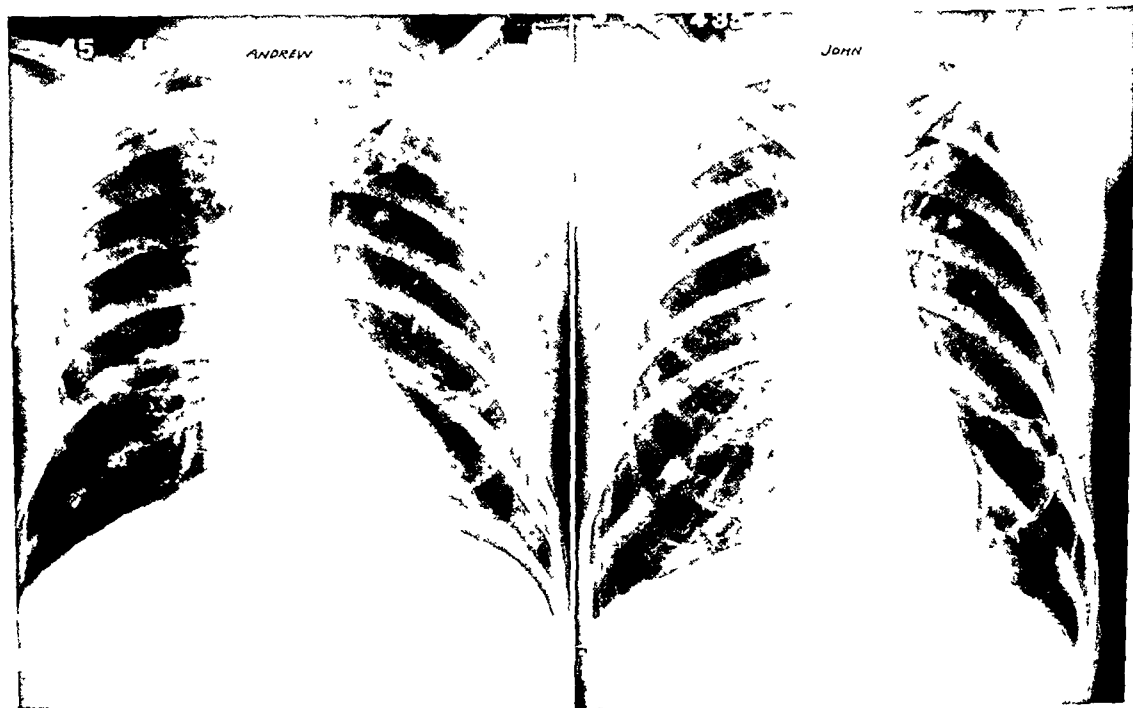


FIG. 2. Roentgenograms of the chests of identical twins A. B. and J. B. Note similar general contour of the ribs, the same patterns and degree of ossification of the costal cartilages.

gested as a possible cause of these changes (Muller). Malformations in rat embryos have been produced by Warkany and Nelson as the result of induced vitamin B deficiency. Gordon and Sang were able to

undesirable. The undesirable mutations are considered pathological. The beneficial changes as viewed over a long period constitute evolution or progress of the race.

Identical (homozygotic) twins are the

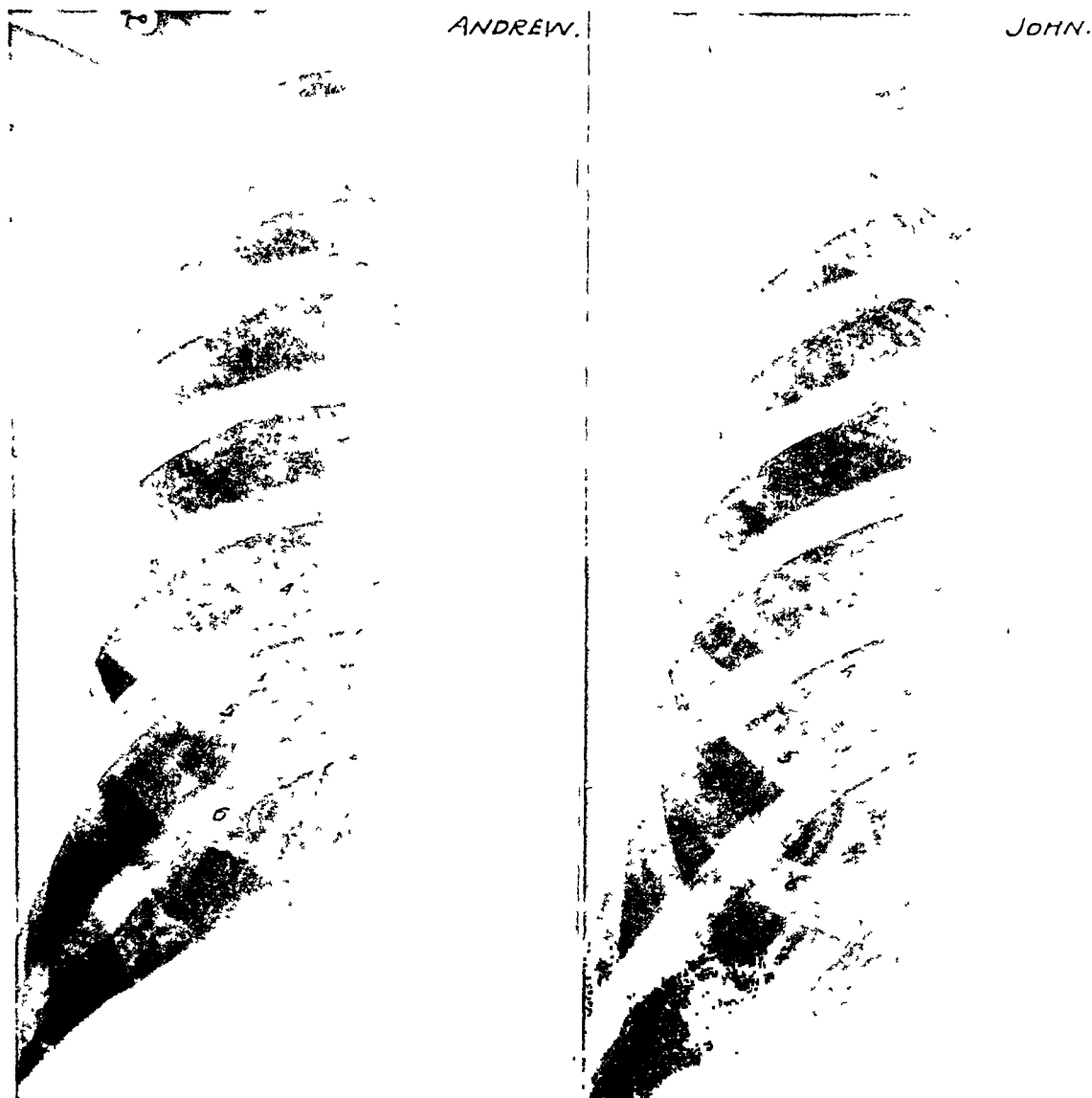


FIG. 3. Enlarged section of the roentgenograms of the right sides of the chests of identical twins, A. B. and J. B. to demonstrate similar patterns of ossification of the costal cartilages.

prevent mutation in fruit flies following exposure to roentgen rays by the administration of niacin. These changes of the genes remain permanently and are carried through succeeding generations. Some of these mutations result in beneficial changes in the offspring and some of the effects are

product of one fertilized egg which has divided. The two halves of this egg, barring deformities or changes incident to environment or acquired diseases, must be identical. The present criteria for identifying twins are:

(1) Blood group—the same.

- (2) Handedness—the same although this may be altered by training.
- (3) Eyes—the same color and pattern.
- (4) Hair—the same color, form, and the same whorl.

The handedness, hair whorls, and skeletal structures are the same in homozygotic twins except in cases of reversal or mirror-imaging in which case these characteristics are reversed.

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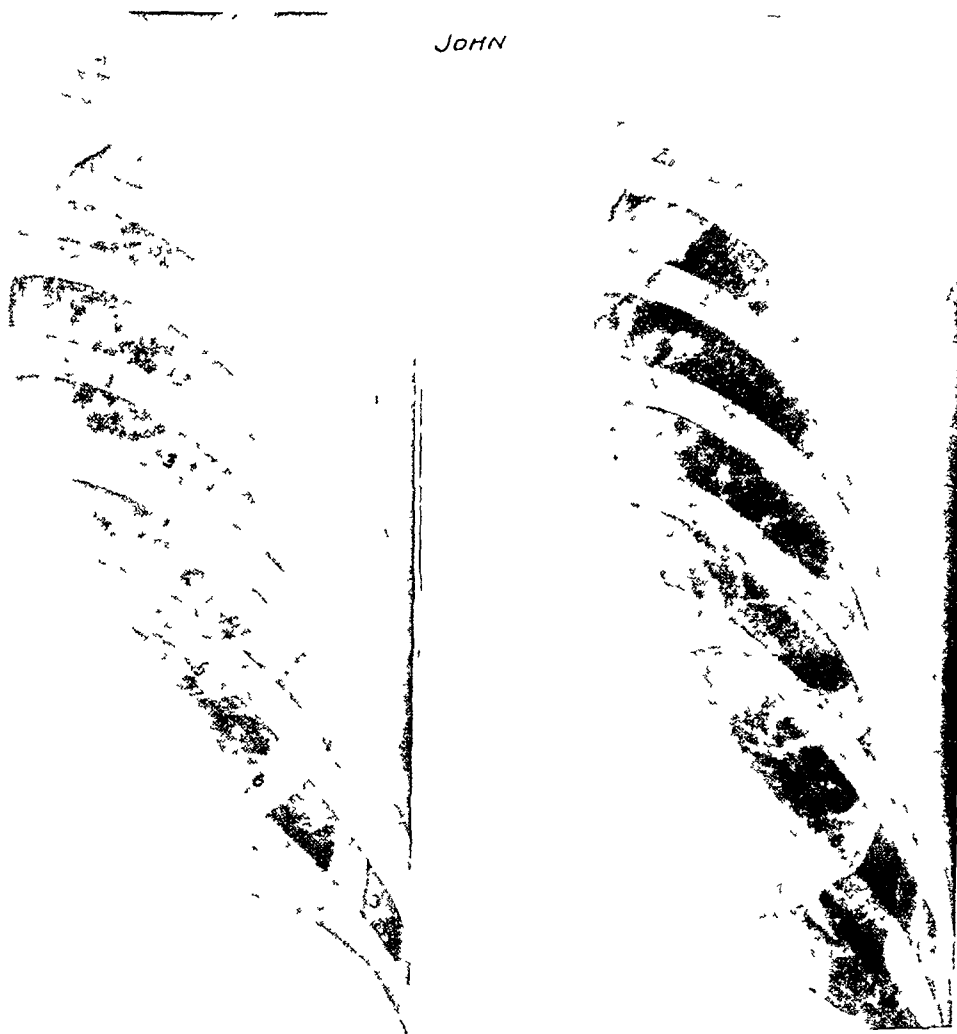


FIG. 4. Enlarged section of the roentgenograms of the left sides of the chests of identical twins A. B and J. B. to demonstrate similar patterns of ossification of the costal cartilages.

- (5) Finger prints and foot prints—the same general patterns although not identical fingerprints.

To these we would like to add a more accurate and precise method of establishing the identity of twins, i.e.,

- (6) Identical skeletal development and patterns of ossification of the costal cartilages as demonstrated on roentgenograms.

GENETIC INFLUENCE IN OSSEOUS DEVELOPMENT

The size, shape and contour of the skeletal system is predetermined by the genes. Even the most minute detail of ossification is under the direct influence of the genes. This fact is evident only when a close comparison of the roentgenograms of each of the respective bones of identical twins is

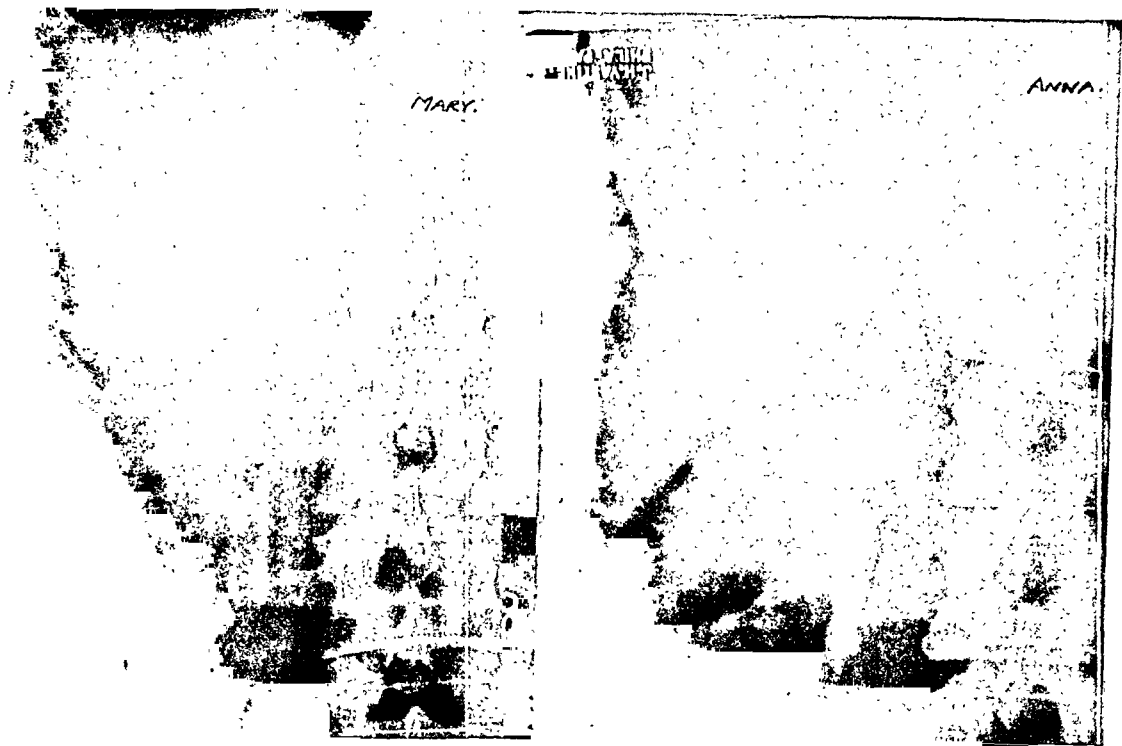


FIG. 5. Identical twins M. S. and A. S., aged fifty-eight years. Roentgenograms of the right lower chest and lumbar spine. Note similar patterns of ossification of the costal cartilages, identical structures of the ribs of both as to size, shape and thickness of cortex. Note the similar shapes, size and directions of the transverse processes of the lumbar vertebrae of the twins.



FIG. 6. Identical twins E. B. and E. S., aged seventy years.

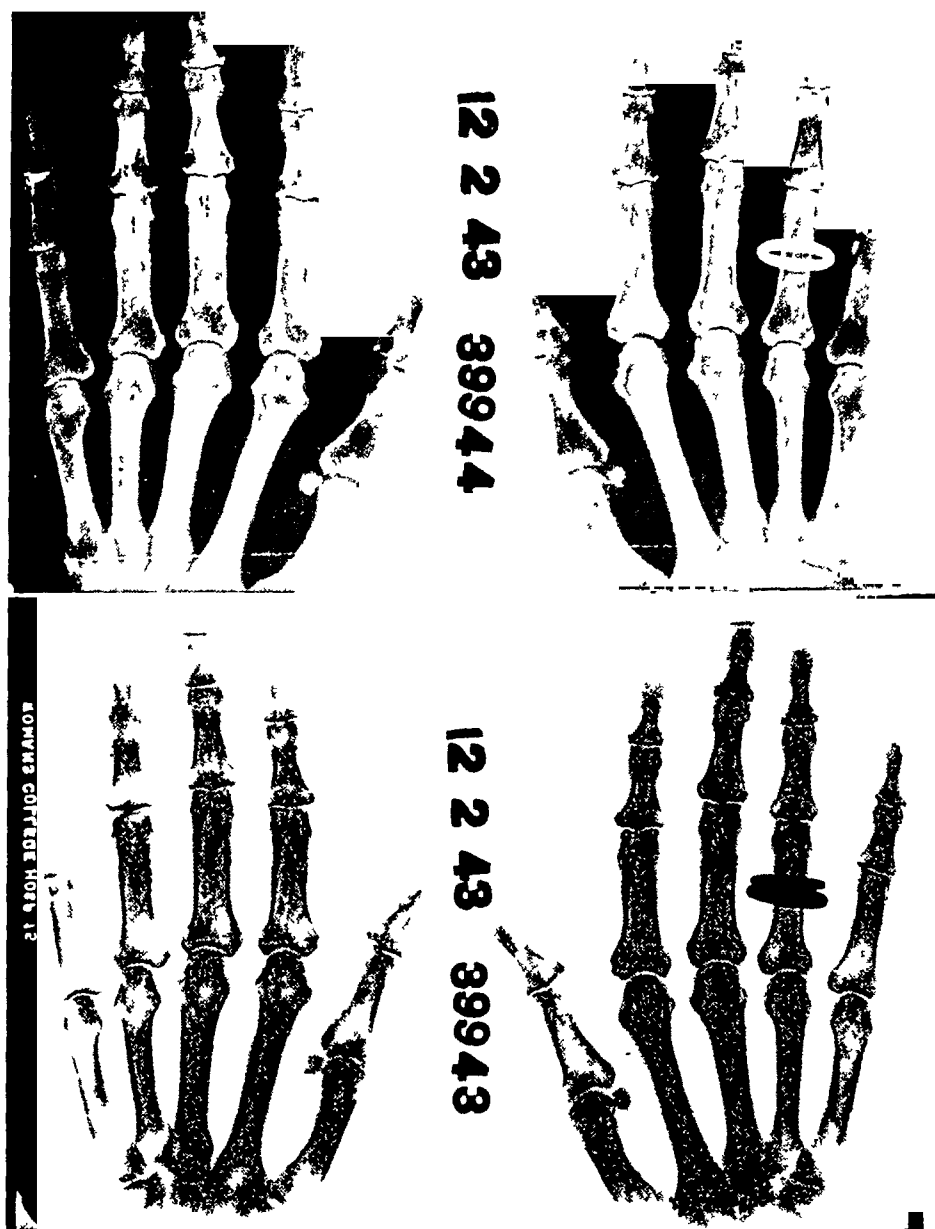


FIG. 7. Roentgenograms of the hands of identical twins E. B. and E. S. Note similarity of the general shape of skeletal structures and the fine bony detail, even to the identity of many of the trabeculations.

made. By such a comparison we will seek to establish the following facts or premises that:

1. The smallest detail of the bony structures of the skeleton is directly influenced by the genes as evidenced by a close comparison of the skeletal structures of identical twins, and that
2. This close similarity as observed on

the roentgenogram may be utilized to identify homozygotic twins. In fact, it may prove to be our most accurate criterion in differentiating homozygotic from dizygotic twins.

3. The ossification of the costal cartilages is under the direct influence of the genes rather than the result of any recent or acquired influence as evidenced by the almost exactly similar

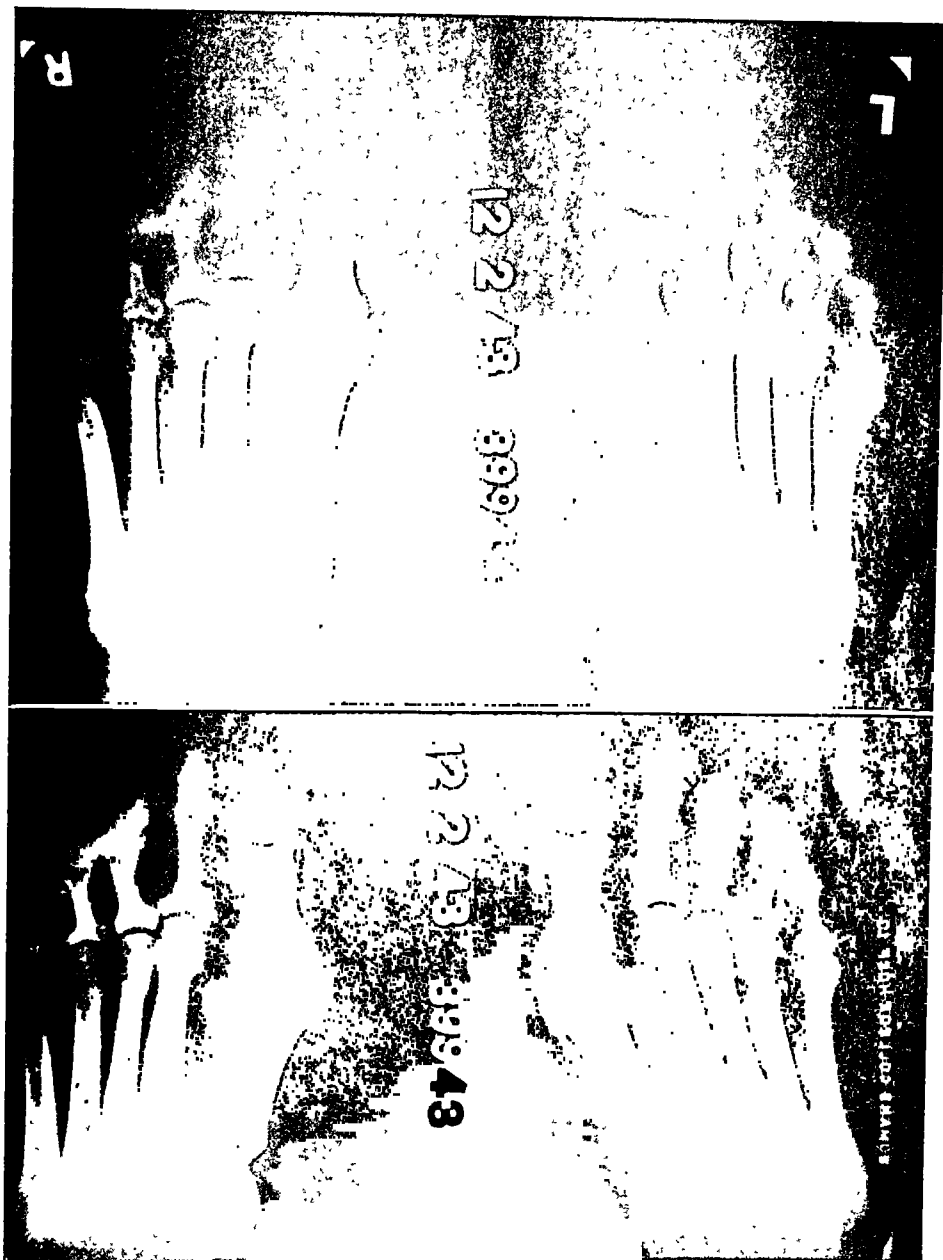


FIG. 8. Roentgenograms of the feet of identical twins E. B. and E. S. Note the similarity of the skeletal structures and similar but not identical degenerative changes of the joints.

patterns of ossification taken in each respective costal cartilage of identical twins.

The third observation is original. Similar observations to one and two were previously made by Rigler and the literature thoroughly reviewed in his study of twins and triplets.

There is exact similarity in the detailed ossification of the costal cartilages as well as in the fine bone detail. The shape of the

ribs, the size, shape, and angulation of the transverse processes as well as the details in other skeletal structures have offered striking likenesses as observed by us in making extensive roentgenological studies of many identical twins. In identical twins in which there is a reversal or mirror-imaging, the skeletal structures and costal cartilages of the one side of one twin are identical to the corresponding structures of the opposite side of the other twin.

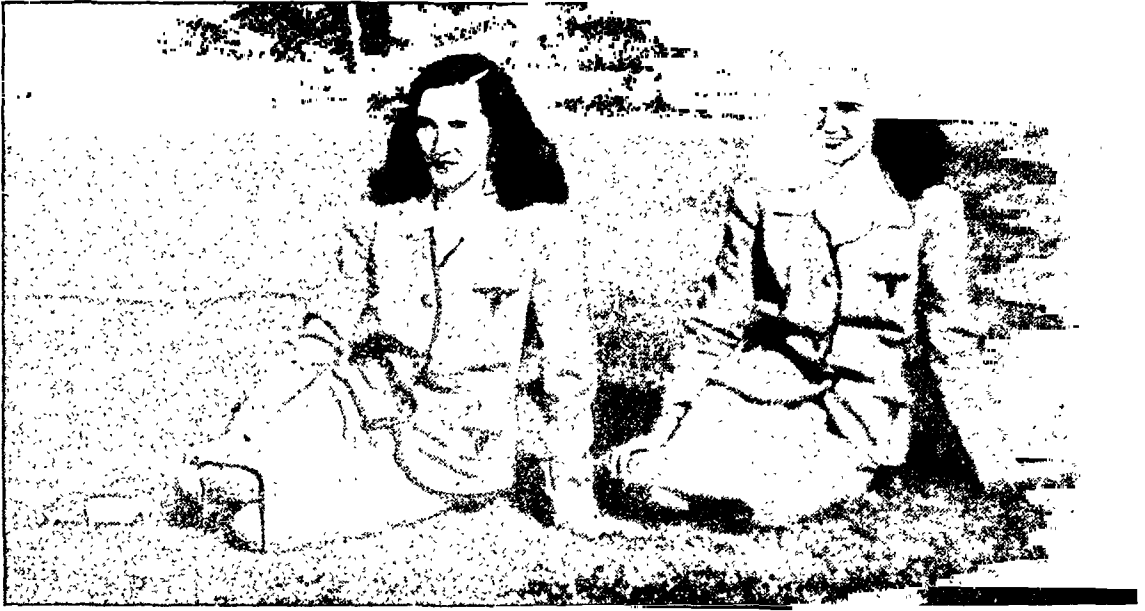


FIG. 9. Identical twins B. M. and M. M., aged twenty-seven years. There is mirror-imaging or reversal in these homozygotic twins as was demonstrated on the roentgenograms.



FIG. 10. Roentgenograms of the lumbosacral spines of identical twins B. M., and M. M. Note (1) that there are six lumbar vertebrae; (2) that there is a spina bifida occulta of the first sacral segment in each twin with the direction opposite in the two twins; (3) that the transverse processes of the lumbar vertebrae on the one side of B. M. correspond to those of the opposite of M. M. in size, shape, length and direction; (4) that the shape of the crest of the ilium of the left side of B. M. is exactly similar to the crest of the ilium of the right side of M. M., and vice versa.

OSSIFICATION OF THE COSTAL CARTILAGES

There are few structures in the human body which have been the source of greater curiosity or more futile conjecture than the costal cartilages. This is probably due to the fact that the chest is the most frequently roentgenographed part of the body and the bizarre patterns of ossification seen in the costal cartilages are often the most striking feature in the roentgenogram.

Ossification progresses in a cephalocaudal direction, usually commencing in the first rib. The center of the cartilage first becomes ossified and later the costal and sternal ends.

These areas of ossification begin in the second decade and become more extensive as age advances. Isolated instances of very marked ossification at an early age have been observed. The cause or significance of this ossification has never been understood. It has been the source of many speculations and considerable investigation. Köhler made extensive observations and attempted to correlate the amount of ossification in the costal cartilages with arteriosclerosis. Ernst, in 1929, reported his observations. Rist, Gally and Trocmé also reported upon the subject in 1928. There are numerous other references to this phenomenon in the literature. Attempts have been made to correlate the degree of ossification in the costal cartilages with (1) susceptibility or resistance to tuberculosis; (2) states of nutrition (it is believed by some observers that ossification occurs at an early age in individuals suffering privations); (3) variations in the mineral metabolism; and (4) endocrine dyscrasias.

We believe that all of these have been erroneous. It was observed by one of us (M. F. V.) several years ago that the pattern of the ossification of the costal cartilages in a pair of identical twins was almost exactly the same. Thus the pattern in the first costal cartilage on the left side of twin A was similar to the ossification in the first costal cartilage on the left side of the twin

B. This similarity obtained in both the amount of ossification and the arrangement.

Since that time we have had the opportunity to confirm these observations by comparing numerous sets of homozygotic twins. We have concluded that since an almost identical pattern or design of ossification occurs in the corresponding cartilages of identical twins, the pattern taken must be transmitted directly by the genes rather than be subject to any acquired factor or to any metabolic, nutritional or infectious influence. Since this has been uniformly true in all sets of identical twins which we have roentgenographed we believe that it constitutes one of our most accurate criteria for identifying homozygotic twins. Since it is such a consistent observation we believe that the ossification design in the costal cartilages is inherited through the genes rather than being the result of a mutation of the genes of a particular ovum before its division.

These observations have seemed to:

- a. Establish the genetic influence as the main factor in the ossification of the costal cartilages.
- b. Offer an easy criterion to aid in identification of homozygotic twins, and
- c. Suggest the pathological insignificance of ossification of the costal cartilages.

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REFERENCES

1. ERNST, G. Die Verkalkungsvorgänge an den Rippenknorpeln. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1929, 39, 485-494.
2. KÖHLER, ALBAN. Grenzen des Normalen und Anfänge des Pathologischen im Röntgenbilde. Georg Thieme, Leipzig, 1931.
3. RIST, E., GALLY, L., and TROCMÉ, C. L'ossification des cartilages costaux dans l'espèce humaine; étude d'anatomo-radiologie statistique. *Presse méd.*, 1928, 36, 641-644.
4. Rigler, L. G. Roentgen studies of twins and triplets. *Radiology*, 1938, 30, 461-470.

AN ANATOMICAL CLASSIFICATION OF CANCER OF THE LARYNX FOR USE IN RADIATION THERAPY*

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THE purpose of this paper is to present an anatomical classification of the clinical stages of cancer of the larynx which has been found to be of value in the prognosis of these cases. It contains no correlation with the microscopic findings but is concerned exclusively with the extent of the lesion at the time of the first complete examination.

One of the principal purposes for this type of classification is to re-emphasize to radiologists that "intrinsic" and "extrinsic" groupings have little importance in the prognosis of these individuals who are treated by means of radiation. "Intrinsic" and "extrinsic" as pointed out by Jackson and Jackson are all-important to the laryngeal surgeon, for, obviously, any lesion that begins or extends beyond the confines of the larynx cannot be cured by laryngectomy. However, from the radiological point of view, in an early lesion of the superior aspect of the aryepiglottic fold one can expect as good a result from irradiation as a similar sized lesion on the true cord. It is the extent of the lesion that is the most important prognostic finding, and not the location. This is not an attempt to decry the laryngologist's approach to the problem, but to point out that the radiologist has a slightly different outlook due to a lack of surgical limitations in his methods of treatment.

The classification that we feel meets most of the needs of the radiologist is shown in Chart 1. As is noted in this chart, the major portions of the larynx are located by name in the usual anatomical positions so that the precise extent of the lesion can be told, and thereby its exact stage. The terms "extrinsic" and "intrinsic" are retained because of their importance to the laryngologist and their widespread usage. A lesion

confined to the right true cord would be termed "Intrinsic Stage I." If a lesion involved the left false cord and the left aryepiglottic fold, it would be called "Extrinsic Stage II" because those are immediately adjacent areas and one is outside the actual larynx.

To follow this classification it is necessary for the patient to have a complete examination of the larynx with direct visualization of the structures by means of the laryngoscope, and an adequate biopsy made. This should be supplemented by soft tissue roentgenograms of the neck. The laryngologist must describe the lesion in terms of the extent of structural involvement, paying particular attention to distinguishing between neoplasm and inflammatory reaction. Following this thorough direct examination and the return of the biopsy report, the exact anatomical classification should be determined. The stage of the lesion at the time of the initial examination should be maintained throughout the entire period of treatment and observation, regardless of regression or progression; that is, a Stage IV lesion may, during proper treatment, shrink to the extent of Stage II, or almost completely disappear, but the records should continue to show it in its original classification, Stage IV. It is necessary for prognostic value that the result of the treatment be evaluated in terms of the lesion as originally seen.

STATISTICAL SURVEY

The following group of consecutive cases has been treated in the Department of Radiology, St. Luke's Hospital, during the period 1936 to 1945. The total number of cases seen is 58. Of these, 4 are excluded immediately because of failure to have

* From the Department of Radiology, St. Luke's Hospital, Chicago, Illinois.

more than one or two treatments. Of the remaining 54 cases the follow-up is not sufficient in 9 to permit inclusion in the final tabulation. Therefore, 45 cases comprise the effective number of cases that are available in this series for statistical evaluation.

The last column on the right of Chart IV shows the overall results of the entire group, and is further elucidated by Table I. Table II shows the age of the cases by decades at the time of the biopsy. The average age of all cases is 57.6 years with the youngest case thirty-four years of age and

CHART I
ANATOMICAL CLASSIFICATION OF CANCER OF THE LARYNX FOR USE IN RADIATION THERAPY

RIGHT			LEFT		
PYRIFORM SINUS			PYRIFORM SINUS		
ARYEPIGLOTTIC FOLD			ARYEPIGLOTTIC FOLD		
Extrinsic			Extrinsic		
.....				
Intrinsic			Intrinsic		
A	FALSE CORD	A C	FALSE CORD	A	
R		N O		R	
Y		T M		Y	
T		E M		T	
E	VENTRICLE	R I	VENTRICLE	E	
N		I S		N	
O		O S		O	
I	TRUE CORD	R U	TRUE CORD	I	
D		R		D	
Intrinsic		E		Intrinsic	
.....				
Extrinsic			Extrinsic		
.....				
THYROID			THYROID		
CRICOID			CRICOID		

- Stage I: Involvement of any one area only
Stage II: Involvement of any two *adjacent* areas
Stage III: Involvement of any two *non-adjacent* areas or any three adjacent areas
Stage IV: Involvement of more than three areas, the regional glands or distant metastases

“INTRINSIC” will be added to the classification when the neoplasm does not extend beyond the dotted lines; if it does extend either above or below the dotted lines at any point then it automatically becomes “EXTRINSIC.”

The classification should be made at the time for the *first complete* examination and not changed during treatment, so that one may evaluate the effect of the therapy in terms of the extent of the original lesion.

Charts II and III graphically demonstrate the results in the 45 cases. They are first divided into intrinsic and extrinsic types and then further broken down into the anatomical stages as described above; Chart II showing the actual number of cases alive and dead at the time of writing, and Chart III showing the average monthly survival for each of the subdivisions. Chart IV shows the results of the same 45 cases when they are broken down into only the anatomical stages and not into the intrinsic and extrinsic types as well.

the oldest eighty-six years. It is easily seen that the onset of this disease is most frequent in the fifth decade of life. Ten patients, or 22.2 per cent, had a tracheotomy while under observation, 6 of them before the treatment and 4 after the series was started. Three patients, or 6.7 per cent, required gastrostomy. Laryngectomy was performed on 2 patients before the treatment and on 2 after treatment. The latter were operated on for local recurrences that probably were not

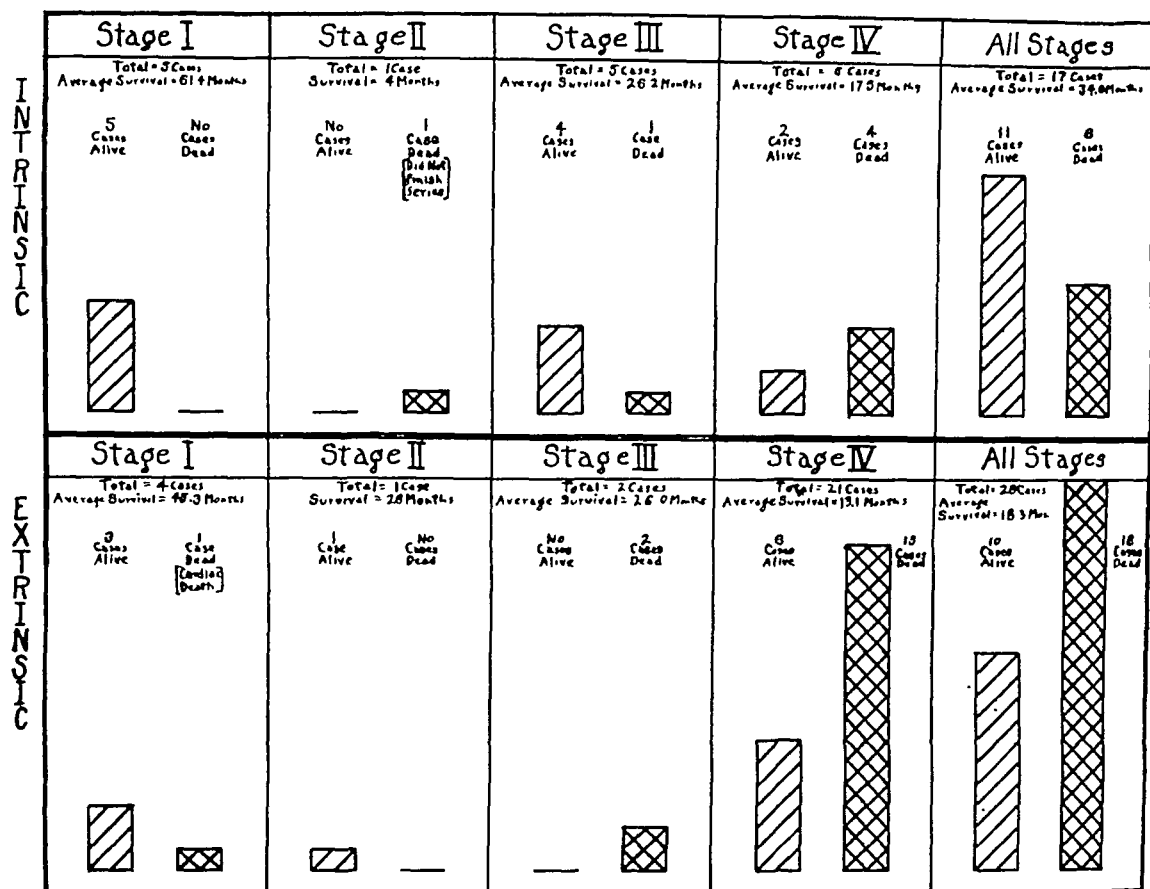


CHART II. Mortality of cancer of the larynx divided anatomically.

true recurrences but new tumors as one occurred some four and one-half years after the original treatment. The former 2 cases had laryngectomy and within short periods local metastatic lesions appeared in the cervical glands.

Two cases, or 4.4 per cent, had laryngeal fissure followed by recurrences in short periods for which the radiation was administered.

Table III shows the three, five, and ten year results of this small series. The per-

centages given refer, of course, to the number of survivals per treated cases that

TABLE II

NUMBER OF CASES PER DECADE AT TIME OF BIOPSY

Years	30-39	40-49	50-59	60-69	70-79	80-89
Number of cases	2	9	14	10	9	1

TABLE III

THREE, FIVE AND TEN YEAR RESULTS

TABLE I

PERCENTAGE SURVIVAL OF ALL CASES

	Cases Dead	Cases Living	All Cases
Number of cases	24	21	45
Average survival	12.2 mo.	36.5 mo.	24.1 mo.
Per cent of total	53.3	46.7	100

	3 Year Observation	5 Year Observation	10 Year Observation
Number of cases	25	15	2
Number of survivals	8	3	1
Per cent survivals	32.0	20.0	50.0

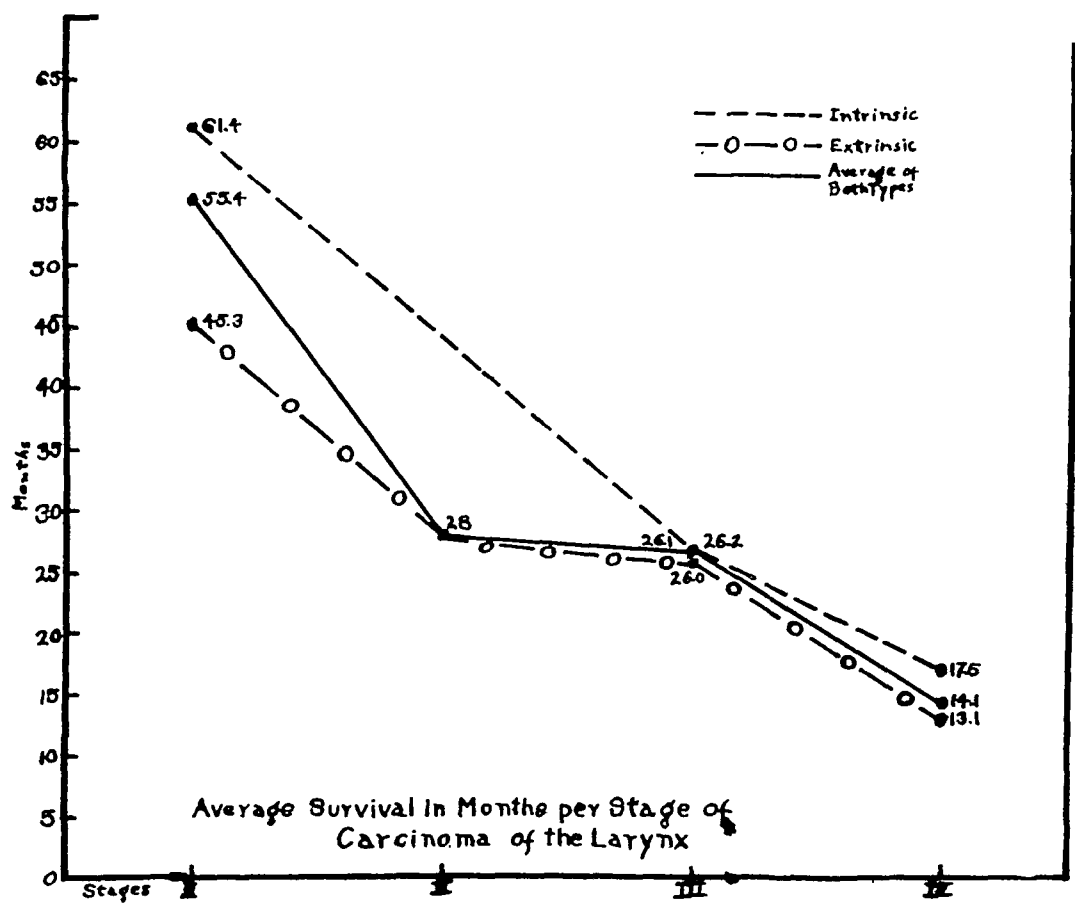


CHART III. Average survival in months per stage of cancer of the larynx.

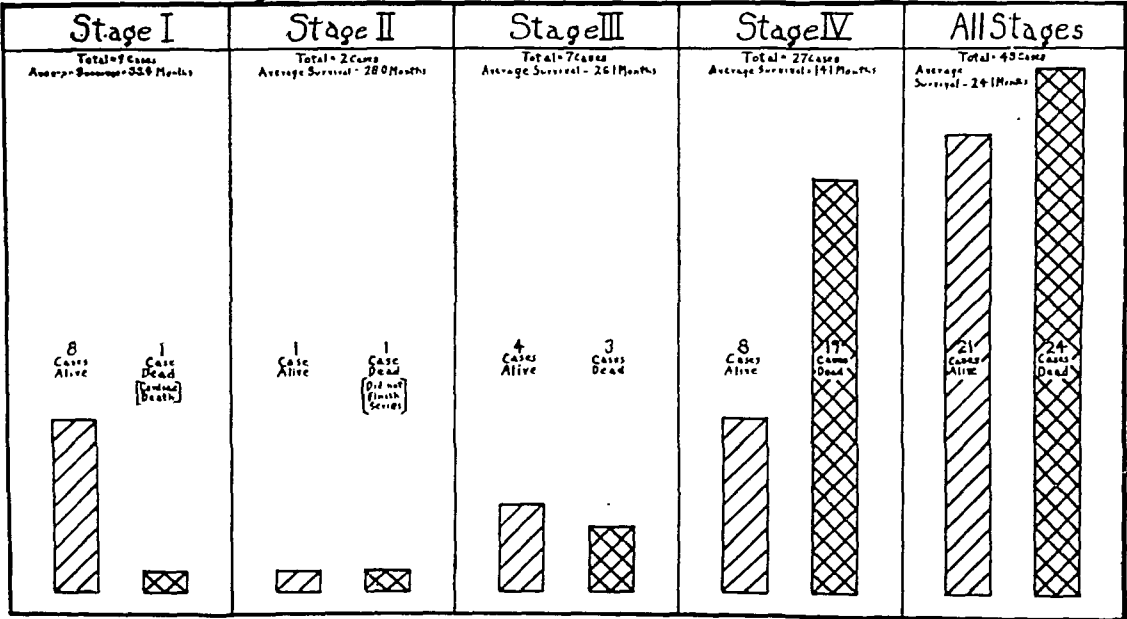


CHART IV. Mortality of cancer of the larynx divided surgically and anatomically.

could have lived that length of time. The ten year survival rate of 50 per cent shows the marked fallacy of dealing with small numbers of cases. The three and five year rates are thought to be reasonably representative of this condition.

TECHNICAL FACTORS

The technical factors used over the years with little variation consist of 200 kv. (peak), mechanically rectified, 20 ma., Thoraeus filter (0.40 mm. tin, 0.25 mm. copper, and 1.0 mm. of aluminum), 50 cm. target-skin distance, a round cone measuring 10 cm. in diameter directed at the mid-portion of the larynx through lateral portals, 20 r per minute delivered with a daily dose of 200 r (measured in air) to a single field. The total air dose to each field is 3,800 r at present. Quimby's depth dose tables give for an average 6 cm. larynx a tumor dose of 102 per cent of the air dose at 3 cm. This gives a total tumor dose of 7,752 r.

Definite evidence of radiation necrosis has not been seen in this series. A marked skin reaction occurs in the majority of the cases but clears quickly at the conclusion of the series of treatment. Edema of the laryngeal mucosa sometimes persists for several months to years, but no permanent untoward results have been observed from this condition.

DISCUSSION

Fifty-eight cases of cancer of the larynx are reported, of which 45 cases have received adequate follow-up to permit a statistical survey with the use of an anatomical classification by extent designed to be of value in the prognosis of cases when treated with radiation.

We wish to make clear that the intrinsic

and extrinsic classification of these tumors offers little of value to the radiologist, but that it is the extent of the lesion when first seen and not the location that is the most important radiotherapeutic prognostic point.

Chart IV shows that of 11 early cases treated with radiation, 2 are dead at the present writing. One of these died of cardiac disease within two months of the completion of the series, and the other had less than half of the projected treatment when he failed to return for the remainder. So that we may say that in the early cases, that is those of small extent which received adequate treatment, we have had no deaths due to the cancer. The laryngologist's report at the time of the last examination of all the early cases shows no evidence of neoplasm in the larynx and the average monthly survival of these cases at the present writing is 55.4 months. Since none of them at present show demonstrable tumor, it is felt that they have a good many more fruitful years of life remaining.

CONCLUSION

1. A consecutive group of 58 cases of cancer of the larynx is presented with a complete follow-up on 45 of the cases, permitting a rather detailed statistical study.

2. The fallacy of radiologists using a surgical classification is pointed out, and a new classification is offered as being of great value in the prognosis of these cases.

3. The authors are quite impressed with the excellent results obtained in the early lesions and have found that the earlier in the disease radiation treatment is instituted, the better the result.

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ACCUMULATION OF BLOOD SIMULATING PRIMARY BRONCHIAL CANCER

REPORT OF CASE

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NUMEROUS factors contribute to production of the density visualized in the thorax on roentgenoscopic study of a malignant lesion in a bronchus. Small tumors in a bronchus frequently cause diffuse areas of infiltration because of atelectasis of the pulmonary tissues, retained secretions, and associated inflammatory reaction, whereas large tumors may reveal small areas of density because of absence of obstruction and infection. Small benign

Diffuse infiltration at the base of one lung revealed by roentgenoscopy with associated diminution in breath sounds is usually thought to be caused by intra-bronchial tumor because of the relative frequency of primary bronchial malignancy. The fact that blood may accumulate in the tracheobronchial tree as the result of suppression of the cough reflex and give rise to findings identical with an intra-bronchial malignant growth is not gener-



FIG. 1. Roentgenogram, May 5, 1946, showing diffuse infiltration at base of right lung, extending from the hilar area.

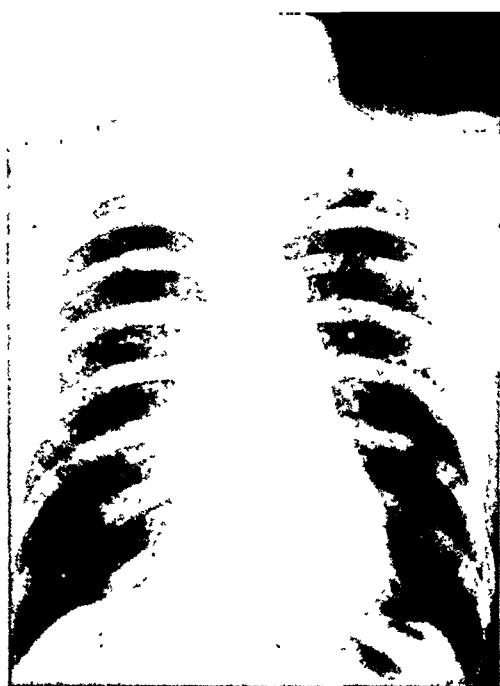


FIG. 2. Roentgenogram, June 5, 1946, showing no abnormality of thorax.

tumors or foreign bodies often produce shadows and cause physical signs that are indistinguishable from those created by the presence of malignant intrabronchial growths.

ally appreciated and prompts the following case report.

REPORT OF CASE

A white male, aged fifty-five, was admitted to Stuart Circle Hospital on May 4, 1946. Al-

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though he was not particularly robust, he considered his health good and had maintained a weight of 134 pounds for several years. In 1918 he had coughed up a small amount of blood that was thought to have come from his nose. For four years he had had occasional, nonproductive cough which had become more pronounced three weeks prior to hospitalization.

On May 1, 1946, on retiring, he began to cough dark, clotted blood and then bright red blood, about a cupful in all. The following day he coughed up another cupful of blood, and on May 4 he expectorated enough blood to fill a large emesis basin. Two doses of morphine were administered hypodermically. He continued to have a slight cough with expectoration of small amounts of bright red blood.

Physical examination revealed impairment of percussion note and diminished breath sounds over the lower lobe of the right lung posteriorly. Roentgenoscopic examination showed diffuse infiltration at the base of the right lung, extending from the hilar area, and the condition was interpreted as primary bronchial cancer (Fig. 1). The patient's temperature

was 100.4° F. Laboratory studies disclosed essentially normal findings, and there was no reduction in the amount of hemoglobin nor in the number of erythrocytes.

Because of the continuation of pulmonary hemorrhage, bronchoscopic examination was performed on May 6, 1946, and after removal of blood clots, active bleeding was found to be coming from a posterolateral division of the bronchus to the lower lobe of the right lung. This bronchial division was thoroughly curetted and dilated, and several cubic centimeters of a 1 per cent solution of neosynephrin were instilled into the bronchial lumen.

Bleeding stopped at once, and for the past seven months the patient has been perfectly well. A second roentgenogram of the thorax on June 5, 1946, did not reveal any abnormality (Fig. 2).

The cause of the bleeding in this patient was simple bronchial erosion.

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RADIOTHERAPEUTIC ERADICATION OF CANCER WITH SURGICAL REPAIR OF SUBSEQUENT ULCERATION AND DEFORMITY*

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THE primary essential in the treatment of cancer is the complete eradication of the malignant neoplasm. The other important consideration is maintenance of subsequent disability, distress and deformity at a minimum. The radiotherapist must frequently chart a precarious course for his patient. On the one hand lies the abyss of oblivion in cancer, while on the other is the devil of post-irradiation sequelae. Threats of trouble from post-irradiation complications in certain cases tend to restrain the therapist from administering sufficient radiation to control cancer, and as a result the patient is victimized by his disease. The complications and sequelae of cancericidal irradiation must be accorded intelligent consideration and discerning judgment by patients, courts and doctors if radiotherapy is to make its full contribution to the control of cancer.

A program of aggressive radiotherapy followed by plastic repair is greatly facilitated by a frankly informed patient and consultation with a cooperative surgeon. Allowing the patient insight as to the true nature and potentialities of his disease usually insures his cooperation, respect and forbearance. The poorly informed patient may at times misinterpret the protective evasiveness of his doctor as evidence of professional incompetence or even malicious deception. In this resentful state of mind, he is more unhappy and morose than the patient who knows that he has a cancer and realizes that strenuous measures must be directed toward control of his disease. As a rule, the informed patient soon develops a

complacent philosophy, undergoes treatment courageously, and accepts the associated inconvenience and complications without complaint. It is highly desirable that the patient be informed as to the slow response of the lesion, the anticipated reactions to irradiation, and in certain cases, forewarned of uncertain healing and the possible need for subsequent plastic surgery. Enlightened forbearance and intelligent cooperation in the patient permit more adequate treatment of the cancer, better management of any ensuing complications, and avoidance of subsequent misunderstandings.

Consultation between the surgeon and radiotherapist is advantageously held prior to administering treatment whenever there is probability of combining irradiation and surgery. In case post-irradiation plastic repair is anticipated, it is well to have surgical consultation preceding radiotherapy. So, likewise, in case postoperative or supplementary radiotherapy seems indicated, the radiotherapist should be consulted before rather than after operation. Pretherapeutic consultation occasionally will modify the therapeutic plan, lead in some cases to treatment by either surgery or radiotherapy alone, and in others to an unanticipated combination of the two methods. Surgery and irradiation should be considered supplementary rather than competitive in the treatment of cancer.

The physiobiology and general management of chronic ulceration occurring after irradiation has been reviewed by us in a previous presentation.²¹ It has been pointed

* From the Department of Radiology, University of Nebraska, College of Medicine, Omaha, Nebraska. Presented before the Twenty-ninth Annual Meeting, American Radium Society, Atlantic City, N. J., June 9-10, 1947.

out that chronic ulceration is contributed to by numerous constitutional, regional, cytological and environmental influences, many of which are not subject to control by the radiotherapist. Persistent or recurrent ulceration is to be anticipated after eradication of cancer in infirm patients, from regions devitalized by poor blood supply, infiltrated by infection, damaged by trauma or invaded by extensive cancer. Such chronic ulcers are not the direct result of excessive irradiation, but rather are due to inadequate recuperability of the tissues. The reference to such lesions as "x-ray burns" by many radiologists and by most surgeons is not only erroneous but also provocative of malpractice suits. Unfortunately, the term "x-ray burn" in the lay mind has implied negligence with gross overexposure and disaster. Chronic ulceration developing subsequent to irradiation is not in itself evidence of faulty radiotherapy.

FACTORS INFLUENCING TISSUE REPAIR

The influences which may contribute to any persistent or recurrent ulceration following irradiation are: (a) constitutional disease—particularly hypoproteinemia, anemia, vitamin C deficiency, arteriosclerosis, and uncontrolled diabetes and syphilis; (b) inadequate blood supply—peculiar to certain regions, reduced by surgical ligation or impaired by previous irradiation; (c) infection infiltrating devitalized tissue by way of surface ulceration; (d) foreign body effect of necrotic bone, cartilage or fascia; (e) trauma, whether actinic, thermal, mechanical or chemical; (f) inadequate regeneration of tissue due to inherent cellular derangement or exhaustion by excessively large diseased area; and (g) residual or recurrent neoplasm. Every precaution should be utilized before, during and following radiotherapy to conserve vascularity, normalize nutrition, minimize infection, avoid unnecessary trauma, and promote the regeneration of tissue. Radiotherapy must be administered in sufficient dosage for destruction of cancer, with an

average requirement of about 7 to 10 erythema doses. The timing and space distribution are to be so regulated as to favor recovery of the normal tissues, as far as possible.^{19,21,36}

The general management of ulceration occurring after irradiation involves observation of the above precautions. Nutritional deficiencies and anemia should be corrected and systemic diseases controlled as far as practical. Ligation of regional vessels should be avoided when possible. Vasodilating drugs have no appreciable effect in the promotion of blood supply through irradiated areas. Peri-arteriolar sympathectomy has been credited with improved circulation and healing of some post-irradiation ulcers.²¹ Infection is minimized by delaying the onset and reducing the severity of acute radiodermatitis through more prompt healing of the skin. Secondary infection is best treated by bland wet dressings fortified by such bacteriostatic or antibiotic drugs as may be indicated.^{21,22} Necrotizing soft tissues can sometimes be eliminated through oxidation with azochloramide or zinc peroxide, or by lysis with allantoin or urea. Sequestering cartilage and bone may be expelled spontaneously or in some cases may require removal by cautery or excision.

The regeneration of epithelium across indolent ulcers is most effectively promoted by radon ointment, as advocated by Uhlmann.^{11,23,34} Had radon ointment been freely available to us, its application might have been effective in healing the majority of the ulcers which we have closed by surgical procedures. A period of two to sixteen weeks is required for the healing of ulcerated areas by radon ointment therapy. The method is reputedly effective in all lesions except those which involve bone and those ulcers complicated by residual or recurrent neoplasm.³⁵ It has the advantage of centering all responsibility in the hands of the radiotherapist. The entire procedure can be done without hospitalization of the patient and necessitates only a weekly visit to the doctor. The total expense will

usually be considerably less than the cost of comparable surgical procedures and hospitalization. Surgical closure can always be resorted to in case the response to radon ointment appears too slow or ineffectual. The possibility of residual carcinoma must be suspected in those ulcers which do not show improvement after three to five weeks of radon ointment therapy.

INDICATIONS FOR SURGICAL REPAIR

It is desirable that ulceration occurring in an irradiated area heal without undue delay in order to relieve the patient from pain, exclude infection from the devitalized tissues, minimize disfigurement and loss of tissue through necrosis, and prevent the development of malignant degeneration. Surgical treatment warrants consideration when ulceration persists for more than eight to ten weeks under good general and local management. A preliminary trial with radon ointment seems warranted in certain cases. Surgical closure is definitely to be considered in all ulceration persisting past three to four months and in cases with extensive necrosis.

Surgical closure of ulceration occurring in irradiated areas has certain advantages.¹³ Excision of the margins and base of the ulcer preparatory to closure provides material for microscopic examination permitting detection of residual neoplasm. The possibility of subsequent malignant change is definitely decreased. The skin will be more durable and have a more normal consistency following surgical closure than with delayed spontaneous healing. Disfigurement can usually be more effectively corrected by plastic repair. The blood supply of the area may be benefited, particularly in those cases closed by a sliding flap or a pedicle graft. Necrotic tissue can be eliminated more promptly. The total period of ulceration is reduced, complete closure frequently being accomplished within ten days by excision and approximation, sliding flaps or split grafts. Lesions requiring pedicle grafts may necessitate two to three months for chain procedures in the

elevation, vascularization, jumping and final attachment of the graft to the recipient area.

It is desirable that the radiotherapist be familiar with the methods and principles of surgical treatment of chronic ulceration^{1,5,10,13,14,17,18,25} in order that he can better evaluate the possible effectiveness of surgical repair in the individual patient, and so that he may cooperate intelligently with his surgical colleagues. This basic knowledge should broaden the radiotherapist's conception of cancer therapy and enhance his value as a consultant. A working knowledge of the possibilities of plastic repair permits the radiotherapist to be more aggressive in the treatment of selected cases of inoperable carcinoma, and it opens a positive hopeful approach in the management of post-irradiation ulceration and necrosis. Not infrequently, there is a tendency to blame previous irradiation for the failure of plastic surgical procedures when the real fault may lie in the surgical technique and clinical management. In such cases, the informed radiologist may offer constructive suggestions for the overcoming of difficulties, rather than mutely accept an explanation that the grafts failed to survive because of the previous irradiation.

PREPARATION OF ULCER FOR GRAFTING

Successful closure of an ulcerating area by plastic surgery requires (1) proper preparation of the ulcer bed, (2) selection of appropriate method or type of graft, (3) preparation of viable graft, and (4) establishment of it in the recipient area. Hypoproteinemia, anemia and other systemic disorders which may seriously retard wound repair should be corrected. Undue delay of soft tissue closure increases tissue loss through progressive infection, reduces blood supply and enlarges the area which must be subsequently grafted. It is essential that cancer shall have been completely eradicated from the ulcer bed; otherwise the graft will fail or cancer will recur subcutaneously beneath the graft. Persistent

cancer is suggested by hemorrhagic, friable induration.

The recipient area must be cleansed of infection and the necrotizing tissue eliminated. Wet dressings fortified by penicillin (200 units per cc.) or tyrothricin (0.5 mg. per cc.) is helpful in the suppression of gram positive bacterial growth. Application of strong antiseptics to the area further damages the already devitalized tissue, thereby increasing necrosis with little, if any, restraint of bacterial growth. Necrotic soft tissues can be partially eliminated through use of azochloramide, activated zinc peroxide, allantoin or urea.²¹ An ointment consisting of 2 per cent allantoin and 10 per cent sulfathiazole in a water soluble base, or a sterile powder composed of one part micraform sulfathiazole in three parts of urea may be helpful in reduction of infection and elimination of some loose necrotic tissue. Electrocautery is useful for the elimination of necrotic soft tissues and is usually followed by alleviation of pain. Debridement, in addition to reducing infection and eliminating necrotizing tissue, exposes healthier vascular trunks, thereby promoting better vascularization and regeneration of granulation tissue. The organizing fibrinous membrane and excess granulation tissue seen in the more recently treated areas must be curetted away or shaved off for exposure of a healthier base to which the skin grafts can be applied. The devascularized and atrophic marginal skin must be excised back to healthy tissue preparatory to attempting surgical closure. Necrotic tissues must be excised from the base until a vascularized bed of viable tissue is exposed. The excised tissue should be examined histologically for evidence of residual neoplasm.

EXCISION AND APPROXIMATION

The various surgical procedures available for repair of cutaneous defects are excision and approximation, sliding flap, pedicle graft, and free skin graft. The simplest procedure is excision and approximation. The use of this method is limited to rela-

tively small lesions and to those lesions which are bordered by abundant loose tissue, as in the mammary area. Success is dependent upon elimination of the diseased tissue and closure without excessive tension. Tension on the flap margins can frequently be relieved by adhesive or an arched bar applying traction 2 cm. or more distal to the line of closure.

Small superficial areas of ulceration frequently heal after electrofulguration and curettement with removal of the necrotic surface layer.

PEDICLE GRAFTS

Pedicle grafts are used for closure of defects from which there has been a loss of subcutaneous as well as cutaneous tissue and in lesions deficient in blood supply. Pedicle grafts were developed primarily by Gillies, who has used the method extensively in reconstructive surgery. Gillies and McIndoe¹⁸ have successfully applied this method to the treatment of radionecrosis, and report that such lesions can be grafted as well as any other indolent ulcer. A pedicle flap is a strip of skin with subcutaneous tissue receiving its blood supply through attachment at one or both ends. The viability of the flap is dependent upon its longitudinal vascularity, which can be increased by preliminary elevation about ten days before transfer. In case the length of the flap is more than two or three times its width, one, two or even more preliminary elevations should be made prior to transfer in order to insure viability and prevent gangrenous necrosis. The improved viability of the delayed flap seems to result, not only from the improved longitudinal vascularity, but also from conditioning of the tissues to lowered oxygen tension.

Pedicle flaps are of various types, such as flat, tubed, gauntlet and lined. A flat pedicle presents a raw subcutaneous surface, while in the tube graft the subcutaneous surface is covered by approximation of the rolled outer margins of the flap. The underlying skin surfaces from which the flap was elevated are sutured together or

covered by a free graft as in Case IX. The lined flap is covered on both surfaces by epithelium and is useful in the closure of perforating defects, such as a hole in the cheek. The undersurface of the flap may be covered by attachment of a split graft, by turning the end of the flap back upon itself, or by means of another pedicle flap. A

greater durability than a free graft. It is particularly valuable for closure of excisional defects in areas of limited tissue with nearby loose tissue, as in the case of the perineum and neck (Case VIII).

The sliding flap can be transferred from an adjacent area in one stage. The transfer of grafts from more remote regions will

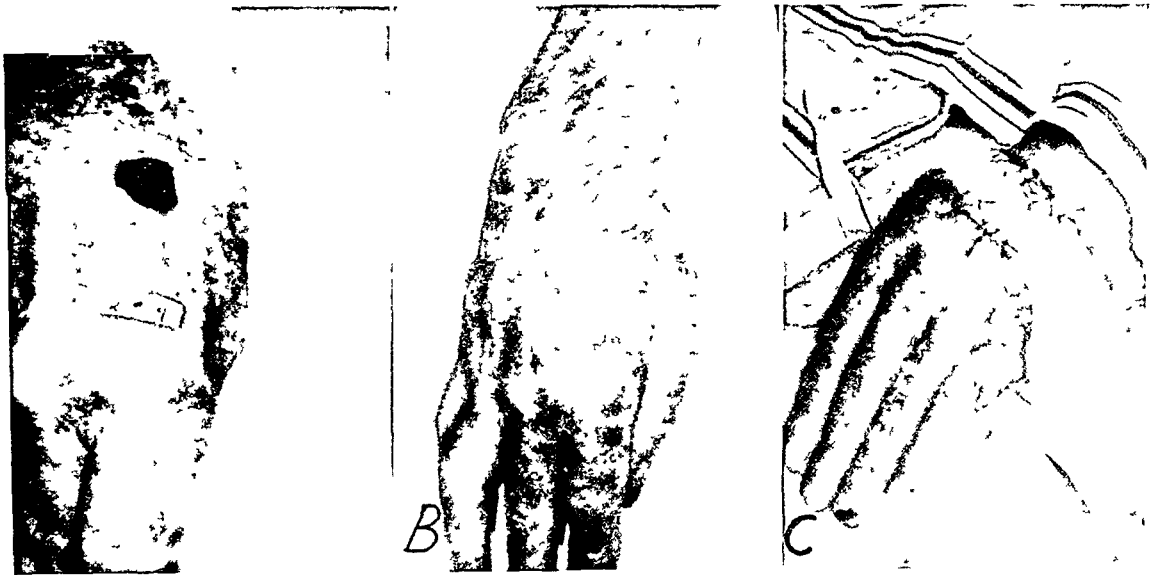


FIG. 1. Case I. W. J., farmer, aged seventy-four. Deep ulcer dorsum of hand repaired by pedicle flap. Squamous cell carcinoma, 3 cm., removed by $4 \times 1,400$ r in tissue, 80 kv. (constant), 2 mm. Al, in December, 1943, healed in eight weeks. A, February, 1944. Necrotic ulceration exposing metacarpal bone developing in healed skin after trauma fourteen months later. Excised ulcer showed no carcinoma. B, July, 1944. Plastic repair by a pedicle flap from abdomen. C, gauntlet type of pedicle flap, adaptable for closure of deep ulcer on dorsum of hand.

gauntlet flap is particularly useful for application of grafts to the hand. The hand is simply slipped beneath the strap of skin which remains attached at each end (Case I).

The sliding flap is a modified type of approximation in which a flap from an adjacent area of looser tissue is swung into the site of excision while remaining attached by a broad pedicle. The secondarily exposed area may then be closed by a split graft or a secondary plasty. This method has the advantage of often permitting immediate closure of a wide defect under less tension than would be possible with direct approximation. Furthermore, it closes a devascularized defect with more certainty and

require two or more procedures. A flap may be jumped to an extremity and thereby carried to the recipient area. The free end of the flap is sutured to the defect and about two to three weeks allowed for vascularization before the base is divided and transferred entirely to the recipient bed. Immobilization between stages is imperative and may require plaster fixation.

The essentials of success in the preparation, transfer and implantation of pedicle grafts are adequate vascularization of the pedicle, avoidance of excessive tension, control of infection, and proper preparation of the recipient area. Vascularization may be inadequate due to the pedicle being too long in proportion to its width or from lack

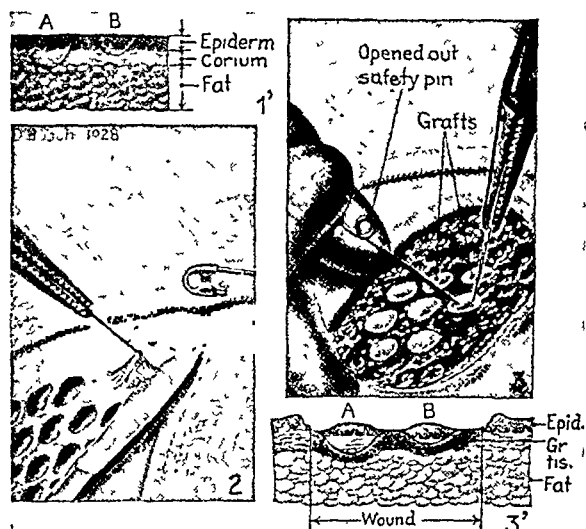


FIG. 2 Technique of sectioning and applying multiple small deep grafts (after Davis).

of preliminary elevation of the flap before transferring it. Constriction of the base of the pedicle by undue torsion or pull from excessive tension will also cause ischemia and may lead to gangrenous necrosis of the flap. The graft should be of proper size and

shape to cover the defect without tension. All those factors enumerated under the physiobiology of ulceration influence the healing of wounds and determine the success of plastic surgery.

FREE SKIN GRAFTS

Free skin grafts are thin epithelial layers which have been separated completely from their original blood supply and placed directly on a freshly exposed subcutaneous surface where they must re-establish vascular communication with the underlying tissue. Free grafts are of three general types: multiple small deep grafts, split thickness grafts and full thickness grafts. The multiple small deep grafts,¹⁵ commonly called "pinch grafts," consist of small discs of skin sectioned by cutting tangentially through a papule elevated with the point of a needle. Peripherally these grafts extend only through the epidermis, while centrally they extend down through the epidermis, dermis and into the subcutaneous tissue, as shown in Figure 2.



FIG. 3. Case 11. G. H., engineer, aged thirty-two. Precautionary application of multiple small deep grafts for prevention of chronic ulceration following intensive radiotherapy to postoperative residual fibrosarcoma of buttock. A, June, 1944. Subacute radiodermatitis six weeks following delivery of 14,676 mg-hr. radium (9,000 gamma r) plus 2,000 r in tissue, 200 kv. (peak), half-value layer 1.0 mm. Cu, during three weeks to a 3 by 5 by 9 cm. infiltrating tumor. B, Two weeks later. Area fully epithelized by multiple small deep grafts with relief of pain (Thick split graft would now be preferred.) Patient well three years later.

The main advantage of the small deep graft is the simplicity of the method and its adaptability in poorly vascularized, somewhat infected areas. The disadvantage is the poor cosmetic result, both in the donor site and on the grafted area, as shown in Figure 3*B*. The full thickness graft has the serious disadvantage of poor viability and loss of capacity for regeneration of epithelium in the donor site. In the case of split grafts, regeneration occurs from the germinal layers of the hair follicles (Fig. 4).

Split grafts of uniform thickness provide the advantages of expediting closure, a good cosmetic result and fairly good assurance of success. The thickness of the split graft may be varied from the level of the epidermis to the deeper layers of the corium. The thin Ollier-Thiersch graft will survive in the least vascular bed, but has the disadvantages of lacking durability and of contracting after application. The deep uniform thickness split graft cut just above the lowermost limits of the corium provides a more durable surface and still permits primary regeneration of epidermis at the donor site. The technique of intermediate split grafts has been developed primarily by Blair and his coworkers.^{3,4,5,6} A split sheet

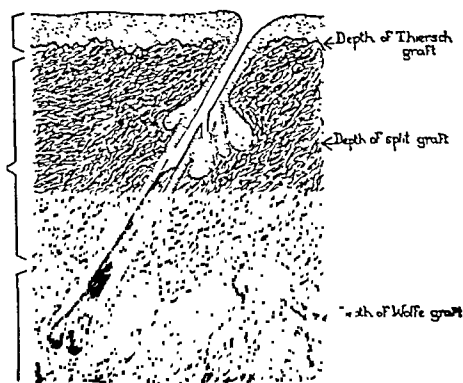


FIG. 4. Diagram of the skin showing different levels of section for various free grafts. Epidermis is regenerated from hair follicles and glands.



FIG. 5. Padgett dermatome glued to donor site preparatory to removal of a split sheet graft of calibrated thickness.

graft can be sectioned freehand according to Blair's technique or sectioned mechanically with the Padgett dermatome.²⁸ The graft must be cut to a size slightly larger than the defect to be closed as some shrinkage always occurs. The Padgett dermatome consists of a metal drum to which the donor skin is glued preparatory to section by the attached razor which is moved to and fro in a fixed slide set at calibrated depths. The thickness of the skin varies with age, being as little as 0.01 inch thick in a child, 0.02 inch in the aged, and as much as 0.04 inch in adults of young and middle age. We have employed grafts of an average thickness of 0.02 inch, classified as deep intermediate split grafts.

Split grafts can be applied to the recipient bed by prolonged application of pressure³ or by thrombin-plasma fixation.^{32,37} The pressure method requires complete hemostasis, exclusion of blood and serum from between the graft and the recipient bed, and the prior elimination of infection from the ulcer bed. Blair advocates a pressure equivalent to 30 mm. of mercury.

Pressure can be applied with sponge rubber or mechanic's waste held in place by adhesive. Occasionally the sutures maintaining the graft in contact with the margins of the bed are tied upward across the dressing to maintain pressure. The success of split grafts has been promoted through the adherence of grafts to the bed by thrombin-

by preventing the accumulation of blood and serum there. It is not necessary to suture the graft to the margins of the donor site in this method, little pressure is needed and in most cases a simple sterile dressing suffices. The area should be protected and immobilized so that the graft is not loosened by trauma or movement.

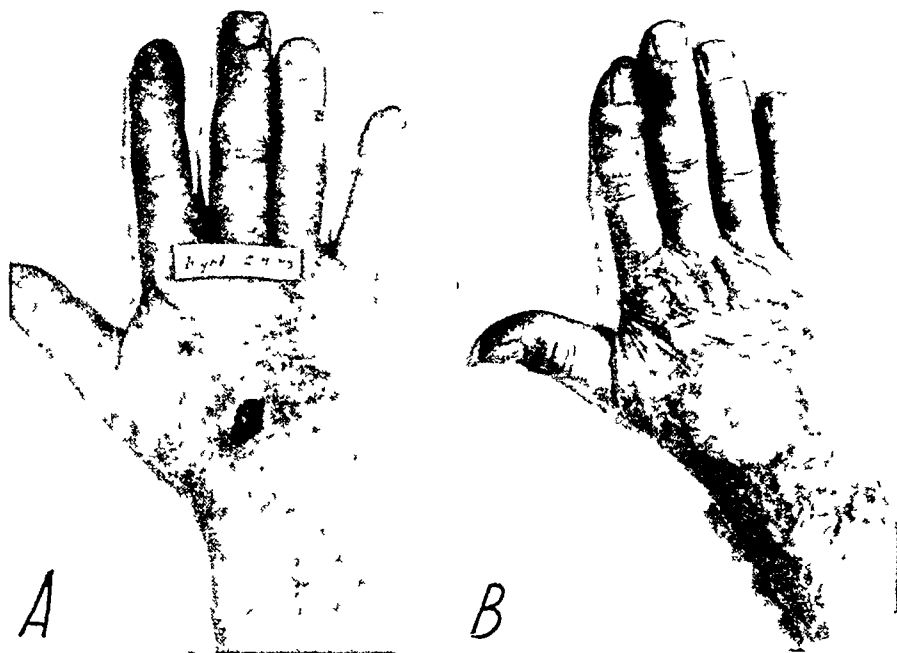


FIG. 6. Case III. A. M., lumberyard man, aged sixty. Ulcer on dorsum of hand repaired by deep split graft. Squamous cell carcinoma, Grade 1, 2.5 cm. across, removed by 3,600 r in tissue, 80 kv. (peak), 0.5 mm. Al., in November, 1941, with prompt healing. A, February, 1944. Ulcer occurring following trauma after being healed twenty months. Biopsy showed no carcinoma. B, July, 1944. Ulcer excised and thick free graft implanted in the base.

plasma fixation. Thrombin is applied to the recipient area, either as a dry powder or in solution (7.5 mg. per cc.). No sulfa powder, penicillin, saline or other material is permitted in the recipient area. Thrombin must be applied immediately before the graft is set in place, since thrombin coagulates blood in two to three seconds. The split graft is immersed in plasma and carefully applied to the recipient area as soon as the thrombin has been applied. The graft must be perfectly placed, since it cannot be moved after being once set in position without breaking its fixation. The thrombin-plasma method eliminates the dead space between the graft and recipient bed.

Successful implantation of a free split graft requires proper preparation of the recipient area, sectioning of the graft through the correct level, and firm adherence of the graft to the recipient bed. Devitalized tissue must have been eliminated from the bed of the ulcer and its margins excised back to healthy tissue. In case the recipient area is fairly vascular, the split graft may be sectioned to the deeper layers of the corium, but definitely not to the subcutaneous tissue. The poorer the vascularity of the recipient area, the thinner the graft needed for viability. The most important detail in insuring successful adherence of the graft is the pressure method of

TABLE I
REGIONAL AND DEVITALIZING FACTORS CONTRIBUTING TO ULCERATION AND NECROSIS

Region Involved by Carcinoma	Hand (5) Fore- head (3)	Ear (3) Nose (2) Lar- ynx (2) Rib (1)	Lip (4) Gum (2)	Vulva (1) Anus (1) Penis (1)	Sar- coma (5)	Neck (3)	Total
Total	8	8	6	3	5	3	33
Persistent ulcer	2	2	1	1	4	1	11
Recurrent ulcer	6	6	5	2	1	2	22
Contributing factors:							
1. Devascularization							
(a) Over bone or cartilage	8	8	2				18
(b) Previous Surgery	4	2	2		5		13
(c) Previous irradiation	2	3	3	1	4		13
2. Infection							
(a) Osteochondritis	2	8	2				12
(b) Contamination			4	3			7
(c) Delayed closure	4			1	1	3	9
3. Trauma							
(a) Mechanical, etc.	6		2			2	10
(b) Sunburn	4	4	4				12
(c) Freezing		4					4
4. Area over 4 cm.	3				5	3	11

implantation has been correct application of even pressure for a period of five to ten days. Insufficient pressure would permit serum to accumulate beneath the graft, separating it from its nutritive bed, with resulting necrosis of the graft from anoxia. Excessive pressure leads to necrosis from ischemia which is the common cause of failure in the thrombin-plasma method.

CASE ANALYSIS OF FACTORS CONTRIBUTING TO ULCERATIONS

The incidence of ulceration following radiotherapeutic eradication of malignant neoplasms will vary from 1 per cent upward depending on the type of case being

treated, the aggressiveness of the therapist, and the timing and space distribution³¹ of irradiation. In our experience, complications occur more commonly in dispensary patients than in private practice, which is attributed to: (1) the more advanced age and poorer general health of clinic patients, (2) greater frequency of previous inadequate surgery and irradiation, (3) more extensive and advanced disease, (4) necessary delegation of many technical details to individuals in training, (5) tendency to concentrate therapy and to reduce the number of treatments, (6) poorer hygiene and more exposure of treated areas to infection and trauma. Even with the best of radiothera-

peutic management, the period of healing will be prolonged and the incidence of recurrent ulceration will rise as efforts are made to control cancer in more advanced stages and eliminate disease from regions of marginal recuperability.

Analysis of 33 cases of ulceration occurring after radiotherapy shows prolonged lack of healing in 11 cases and recurrent ulceration occurring one month to six years after complete healing in 22 cases (Table 1). Recurrent ulceration occurred most frequently in those areas exposed to trauma by abrasions, as the hand and lip, or by blistering sunlight and freezing weather, as the lip, nose and ears. Trauma precipitates ulceration through introduction of infection into tissues of impaired vascularity. Tissues sustained by a barely subsistent vascularity or lacking in inherent recuperability are especially susceptible to virulent surface infections as in the hypopharynx or to persistent contamination as on the perineum. Vascularity may be reduced by previous incomplete surgery (as in 13 cases) or previous inadequate irradiation (13 cases).

The regions most commonly involved by recurrent ulceration are those composed of a layer of skin directly over bone or cartilage with little subcutaneous tissue. The arterioles in such areas as the dorsum of the hand, temple, scalp, nose, ear and gums, are of small size, and therefore particularly susceptible to stenosis by irradiation. Furthermore, there is a lack of nourishing subcutaneous tissues with no collateral deep circulation. All 11 cases showing persistent ulceration following eradication of neoplasms had lesions over 2.0 cm. across. In 8 cases the lesion was over 4 cm. in diameter. These large lesions deplete the regenerative capacity of epithelial and vascular tissues and widely expose the subcutaneous tissues to prolonged surface infection. In 3 cases lack of initial healing was due to associated infection of bone and cartilage (ear, costochondral junction, jaw). Altogether, infection of cartilage or bone was associated with post-irradiation ulcer-

ation in 12 of the 33 cases. In 3 cases chronic infection was aggravated by maceration and contamination (penis, vulva and anus). In other words, all irradiated lesions less than 4 cm. in size healed initially except those complicated by active infection in bone or cartilage. Perineal lesions healed very slowly and insecurely. Persistent or recurrent ulceration also may result from residual or recurrent neoplasm which can be differentiated by microscopic examination, and then only eight to ten weeks after therapy. Evaluation of the adequacy of radiotherapy will aid in differentiation between possible cancer and trophic ulcer, but is not fully conclusive.

CANCER OF THE HAND

Recurrent ulceration has been encountered on the dorsum of the hand in 5 cases after radiotherapeutic eradication of carcinoma. The disease usually has occurred in farmers and outdoor laborers well past middle age.³⁰ The skin is atrophic and devascularized from age and scarred from repeated trauma. The small caliber of arterioles and lack of subcutaneous tissue makes the region more vulnerable to irradiation and susceptible to trauma. Previous treatment had consisted of incomplete surgical resection in 4 cases and inadequate irradiation in 1 case. Carcinoma of the hand under 2 cm. and freely movable can be effectively eliminated by excision or irradiation. Excision is expeditious and provides a durable surface, although grafting is often necessary for closure. Lesions previously irradiated ineffectively are better excised and grafted since further irradiation commonly eventuates in subsequent breakdown after minor trauma. Lesions over 3 cm. and fixed to deep fascia are eliminated with more assurance by radiotherapy than by dissection.^{7,30} Subsequent surgical repair may be needed to hasten epithelization and exclude infection. Bradon⁷ reports remarkably uniform elimination of cancer from the hand with good healing of the skin in a series of 200 cases treated by low intensity radium moulds

continuously for two consecutive periods of seven days each. The secret of this success probably lies in the low intensity and in the good space distribution of radiation. In our cases which broke down following irradiation to cancer of the hand roentgen treatment was condensed to about four days or less and fractionation reduced accordingly.

ing bone, thereby predisposing the soft tissues to avascular necrosis following irradiation with exposure of the bone to infection. The basal cell lesions in this area progress slowly at first, seem innocuous, and may be neglected by the patient until quite extensive.

If the carcinoma is under 2 cm. and

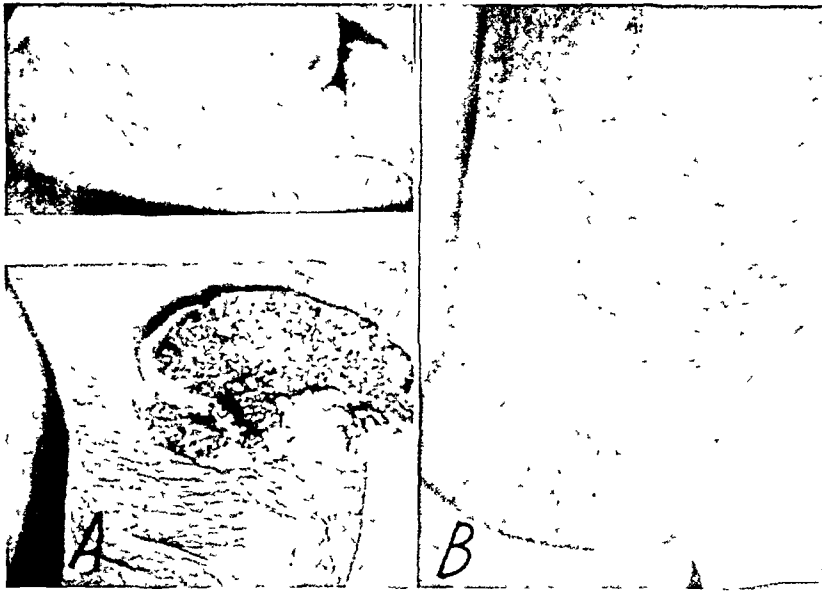


FIG. 7. Case IV. G. M., farmer, aged eighty-two. Large infiltrating cancer of wrist, destroyed by roentgen irradiation with delay of healing. *A*, August, 1943. Fungating, excavated mass, 3 by 6 cm., received $6 \times 1,200$ r in tissue, 70 kv. (peak), 1 mm. Al. *B*, October, 1945. Slow gradual healing required fifteen months. Plastic repair refused.

In retrospect we feel that a lower daily dose and more fractionation would have promoted recovery without danger of persistent cancer.

Choice of method for repair of the dorsum of the hand depends on extent and depth of lesion. Few lesions are small enough for closure by approximation. Split grafts are expeditious and satisfactory for nearly all lesions on the hand (Case III). Pedicle flaps are considered only for lesions needing subcutaneous tissue, as on the palm or deeply excavated lesions (Case I).

CARCINOMA OF SCALP

Carcinoma of the forehead, temple and scalp also presents the problem of cancer occurring in a shallow vascular bed overly-

movable over bone, healing usually follows radiotherapy. If the lesion is over 3 cm., or fixed to bone, delayed healing and possible osteomyelitis with exposure of the skull may eventuate. Surgical closure over such areas of osteitis is usually unsuccessful. Primary surgical excision with closure by a sliding flap or split graft will usually close these larger scalp lesions unless there is invasion of periosteum or bone.

In case the lesion is fixed by infiltration of the periosteum or skull two methods of treatment are possible. The lesion can be treated by surgical resection down to the bone followed, first, by electrocoagulation of the outer table, then, by removal of the dead bone. This will expose the vascular diploic spaces which furnish a good bed for

a split graft. In case the lesion is treated by fractionated short distance radiation and healing is not occurring within six to eight weeks, the above surgical procedure may permit closure before osteomyelitis becomes established. Depth delivery should be kept low to minimize irradiation of the brain.

CARCINOMA OF NOSE

Carcinoma involving the bridge of the nose presents the problems of a shallow

unsuspected burrowing of cancer cells beneath the skin²⁷ and beyond the limits of therapy. Re-irradiation of the already devascularized tissue may be followed by slow healing or ulceration. Excision of recurrent and atrophic scar down to periosteum with immediate application of a thick split graft, as from behind the ear, will effectively control many lesions on the bridge of the nose. The repair of perforating lesions of the nose, and rhinoplasty in



FIG. 8. Case v. R. B., housewife, aged sixty-three. Restoration of facial contour with prosthesis. *A*, nose destroyed by syphilis and previous escharotic therapy for "cancer." *B*, nasal prosthesis prepared by Dr. A. M. Brown, Chicago, Illinois.

vascular bed and possible involvement of underlying bone. The nose develops an epidermolysis of both skin and mucosa, thereby opening entry for infection on both surfaces. We have seen infection enter from the mucosal surface into bone and perforate through to the skin. We endeavor to avoid irradiation of the septum and deeper tissues of the nose as far as possible by directing radiation tangentially and by introduction of lead foil covered by a lubricated finger cot upward along the septum. Recurrence of cancer of the nose following surgical and radiation therapy commonly results from

general, requires unusual skill and experience in the use of lined flaps, bone grafts and other special plastic techniques. Prostheses replacing the nose in whole or in part can be fashioned from latex, duroc and other plastics by experts or in cooperation with an interested and well equipped dental laboratory,^{8,9,33} as shown in Figure 8.

CARCINOMA OF THE EAR

The auricles of the ear and ala nasi likewise present only a thin layer of skin directly overlying cartilage. These areas

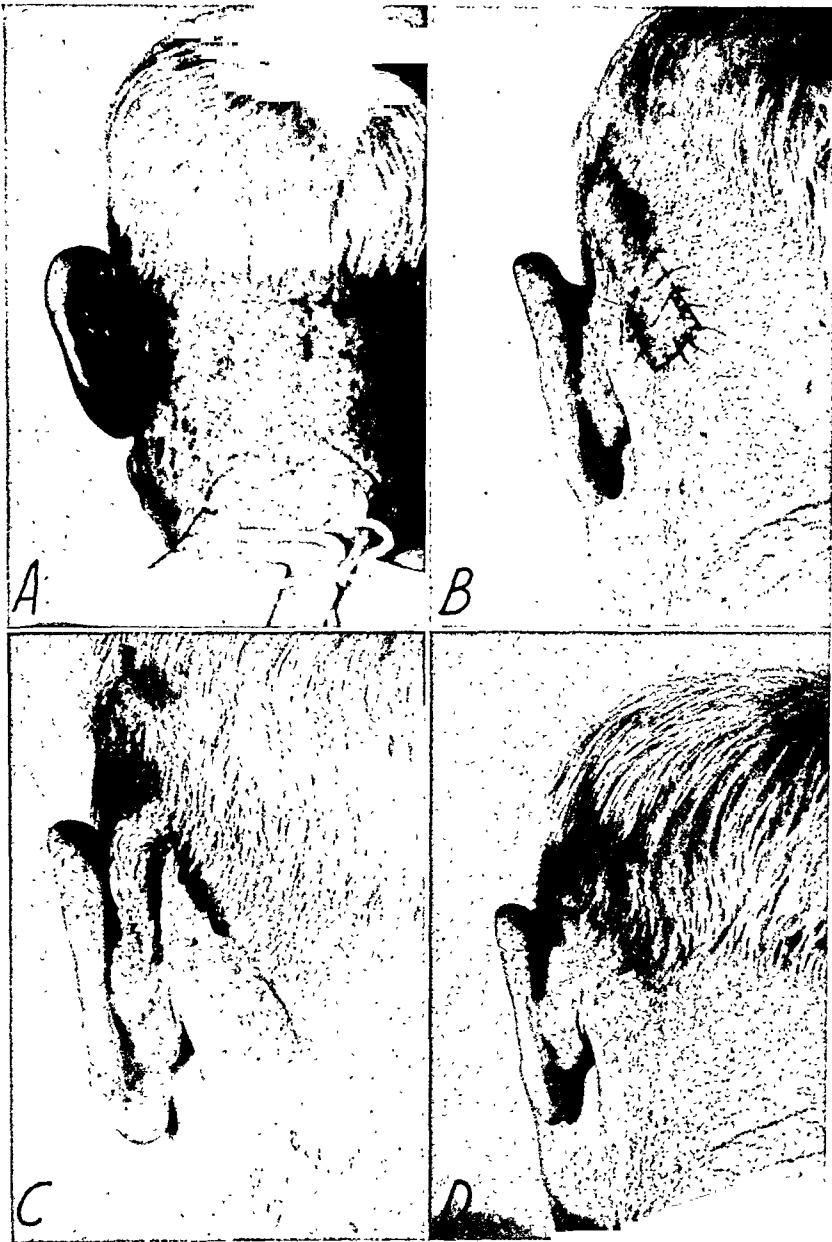


FIG. 9. Case VI. Js. B., laborer, aged sixty-nine. Necrosis of auricular cartilage following eradication of large carcinoma; chondritis excised, and defect closed by two-stage pedicle graft. *A*, November, 1943. Ulcerating mass on dorsum of ear, 2 by 4 cm., treated by $6 \times 1,050$ r in tissue, 80 kv. (peak), 0.5 mm. Al. Enlarged cervical nodes treated by radium interstitially—3,440 mg-hr. (8,600 gamma r). History of previous inadequate radiotherapy. *B*, July, 1944. Fair healing followed by ulceration exposing infected cartilage. Preliminary elevation of pedicle. *C*, two weeks later, Devitalized cartilage and skin excised. First stage transfer of pedicle flap. *D*, November, 1944. Completed transfer of graft and preservation of ear with excellent cosmetic result. Remains well in June, 1947.

not infrequently break down following concentrated irradiation due to endarteritic stenosis of the small vessels, predisposing to infection commonly introduced by freezing or sunburn, and resulting in a

painful chondritis. In some cases of painful chondritis, we have removed infected necrosing cartilage for relief of pain and to permit healing of skin using scalpel or electrosurgical loop. Occasionally, it may be

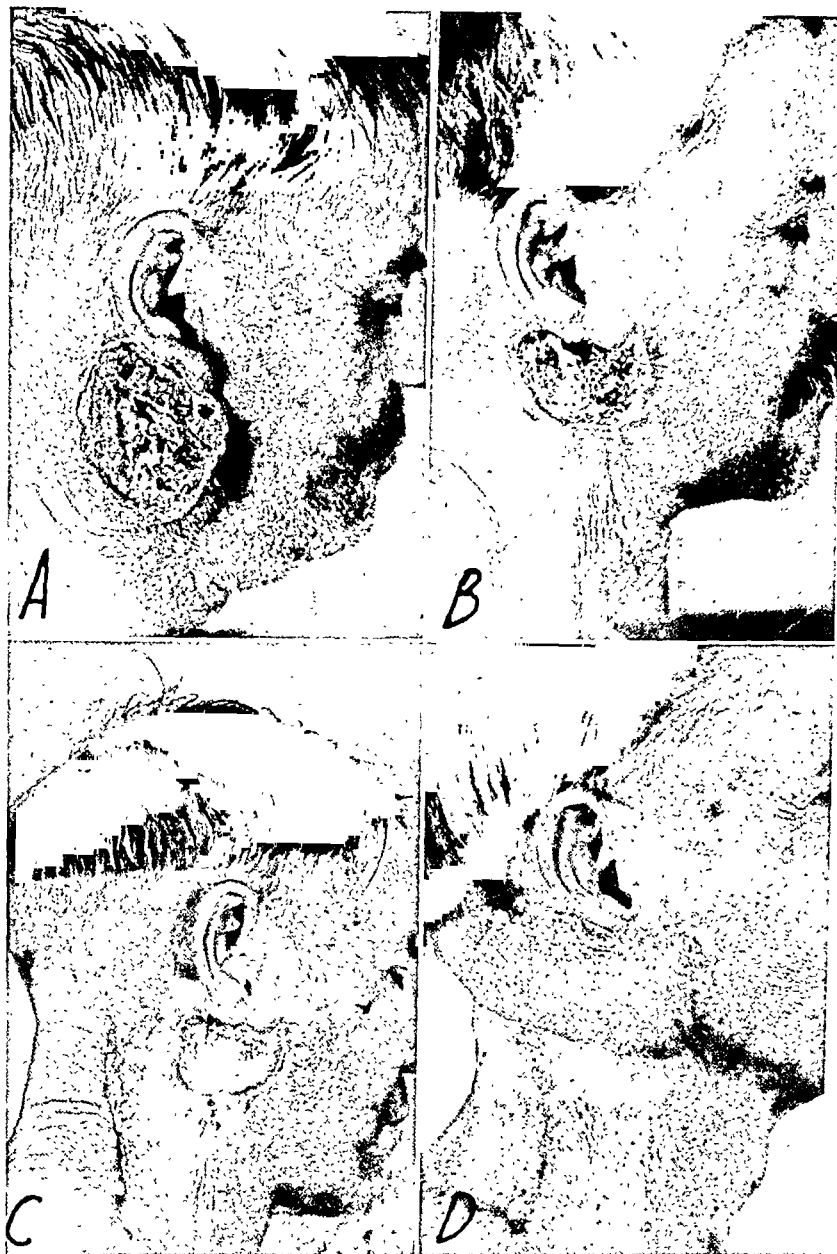


FIG. 10. Case VII. B. O., laborer, aged sixty-four. Large carcinoma of neck eradicated by roentgen and radium therapy. Repair of recurring ulceration by sliding flap with closure of donor site by split graft. A, ulcerating necrotic mass, 3 by 6 by 8 cm., received 12×450 r (5,400 r) in tissue, 180 kv. (constant), half-value layer 1.0 mm. Cu, plus 6,567 mg-hr. interstitial radium (5,000 gamma r) from July 13 to August 14, 1944. B, nine months later. Recurrent extension of ulcer after initial incomplete healing. C, pedicle flap elevated, and donor site covered by free split graft. D, ulcer excised, area closed by sliding flap. Well three years later.

possible to preserve the contour of the ear, as in Figure 9, Case VII. Some radiotherapists have claimed that cartilage was spared by high voltage, heavily filtered roentgen rays²⁶ and gamma rays.²⁴ It seems more probable that the better texture of tissues and lower incidence of break down

is from lower intensity and greater fractionation rather than from shorter wave length. Cancer of the ear^{16,24} and cancer of the nose²⁹ have been successfully treated by radiotherapy, but do carry some danger of subsequent chondritis, especially when fixed to underlying structures.



FIG. 11. Case VIII. Jn. B., confectioner, aged sixty-nine. Very large squamous cell carcinoma of neck eradicated by deep roentgen and radium therapy with very slow spontaneous healing. Patient refused transfer of pedicle flap raised in anticipation of surgical closure. *A*, April, 1944. Necrotic fixed mass, 5 by 7 by 10 cm., treated tangentially by 18×250 r (total 4,500 r) in tissue, 180 kv. (constant), half-value layer 2 mm. Cu, plus 3,218 mg-hr. interstitial radium, 0.5 mm. Pt (4,100 gamma r), all given from April 17 to May 17, 1944. History of previous inadequate radiotherapy. *B*, July, 1944. Carcinoma eradicated, ulceration persists with delayed healing. *C*, anticipatory tubed flap elevated from pectoral region was not utilized. *D*, July, 1946. Patient well, no evidence of carcinoma. Irradiated area healed slowly after one year. Patient refused surgical closure.

CARCINOMA OF LARYNX

Ulcerating carcinoma contiguous with the cartilage of the larynx presents even more difficult problems. We have encoun-

tered two fatal hemorrhages from recurrent ulceration of the larynx six months after irradiation by the "concentrated technique." Again, we believe that lower inten-

sity and more fractionation favor recovery of normal tissues and reduce the incidence of ulceration and chondritis. Radiotherapeutic eradication of carcinoma of the larynx actually infiltrating cartilage will usually be followed by a continuing chondritis and sore throat which may eventually heal, once diseased cartilage has been expelled. A laryngectomy done one year after irradiation resulted in complete break down of all suture lines. Special attention must be given to level of blood protein and adequacy of nutrition essential to wound repair in the case of cancer of the mouth and throat. Re-irradiation of carcinoma of larynx or hypopharynx carries greatly increased danger of subsequent chondritis, necrosis, edema and hemorrhage.

CARCINOMA OF THE MOUTH AND JAW

Carcinoma of the mouth adjacent to the jaw can usually be treated without too much hazard of osteomyelitis, providing teeth are extracted first. Extraction of teeth one month to ten years after intensive irradiation has led to sequestering osteomyelitis of the jaw lasting for years and being aggravated by carotid ligation for control of hemorrhage. Since osteomyelitis and sequestration are to be expected in case there is actual invasion of the alveolus by cancer, in such cases electrocoagulation of the diseased bone will hasten its separation and allow more rapid closure of the wound. Osteitis of the alveolus usually is a self-limiting disease. Fractionated intraoral roentgen therapy and preliminary extraction of all sound, as well as diseased teeth in the exposed area has reduced the incidence of sequestering osteomyelitis of jaw. Of course, the alveoli must be shielded when the lip and cheek are irradiated or a similar alveolitis may develop by way of dental sockets from pyorrhea or following extraction.

Perforation of the floor of the mouth or cheek following osteomyelitis or disintegration of a penetrating tumor usually can be closed by an expert plastic surgeon with a

lined flap or plugged by a special prosthesis.

CARCINOMA OF THE LIP

The lip tolerates irradiation well and chronic ulceration is seen only after intensive re-irradiation following repeated blistering sunburn or trauma from misaligned or jagged teeth. Delayed breakdown occasionally follows irradiation of superficial linear ulcerations occurring in an atrophic mucous membrane seemingly sensitized to and repeatedly blistered by sunburn. In our experience this type of linear lesion may be excised by undercutting the mucosa with direct re-approximation of mucosa to vermillion border of the lip. Such lesions occurring in atrophic mucosa usually heal following roentgen irradiation or electrocautery, but ulceration may recur after blistering sunburn and adjoining areas often break down subsequently. Carcinoma of the angle of the mouth heals slowly due to wrinkling and unfolding with talking and eating. A collodion dressing may aid through fixation of the area.

Irradiated lips should be protected against freezing and shielded against blistering sunlight by a broad hat or protective salve. Jagged or misaligned teeth should be smoothed by an abrasive disc or extracted. Small superficial ulcers may heal following electrofulguration and elimination of irritation. Closure of deeper and more persistent ulcerations, and especially those recurring after previous irradiation, is expedited by surgical excision and approximation. It is particularly important that the section be carried into healthy tissue and that tension on the approximated devascularized margins be relaxed, if healing is to be secure. Tension is readily relieved by an arched traction bar. Excision of longitudinal ulcers with re-approximation of mucosa to the vermillion border has already been discussed. Excised tissue should be examined for cancer since submucosal recurrence may occur after seemingly adequate therapy. Primary surgical resection is to be considered in lesions of

the lip which are recurrent after previous intensive radiotherapy, cancers associated with destructive ulceration necessitating subsequent plastic repair and superficial linear ulcerations occurring in an atrophic light-sensitive mucosa.

CARCINOMA OF VULVA, PENIS AND ANUS

Carcinoma can be eliminated effectively from the anus, vulva and penis by irradi-

not suitable for radiotherapy. We have successfully eliminated inoperable vulvar lesions by low intensity interstitial radium, and with durable healing. Painful ulceration persisting following irradiation closed by simple excision and approximation recurred and a sliding flap was required for sufficient relief of tension to permit durable closure.

Papillary or superficial carcinoma of the penis can be eliminated by irradiation with

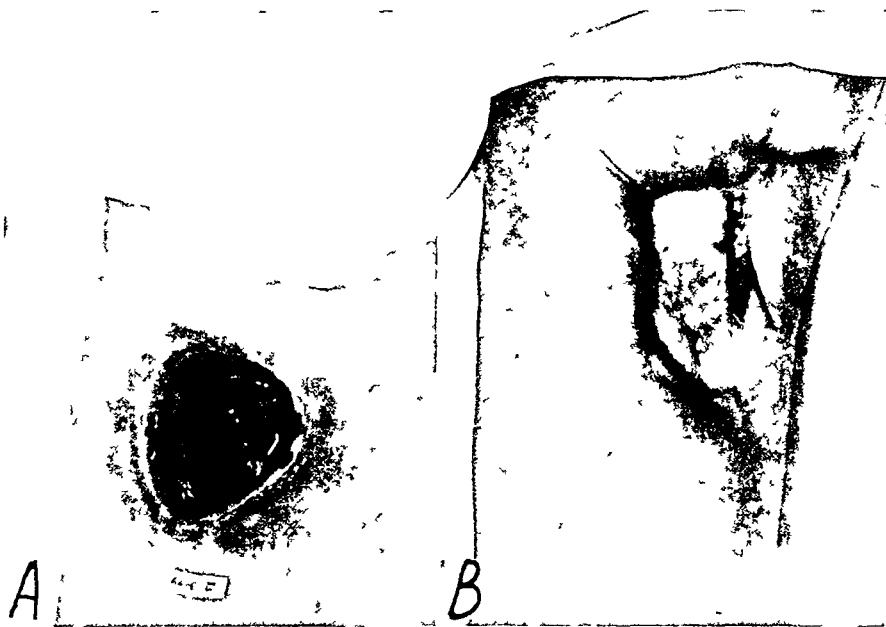


FIG. 12. Case IX. D. H., housewife, aged thirty-nine Neurofibrosarcoma, recurrent after two resections and 3,300 r in tissue, 180 kv. roentgen therapy. Eradicated by combined radiotherapy and ulcer repaired by free split graft. *A*, necrosis 5 by 7 cm in posterior thigh, four months after 15×225 r (3,375 r) in tissue, 180 kv. (constant), half-value layer 1.0 mm. Cu followed by 6,060 mg-hr., 0.5 mm. Pt interstitial radium (6,000 gamma r) in five days, all delivered from August 24 to September 21, 1943. *B*, three years later. Area remains well healed after closure by free split graft. No recurrence or metastases.

ation, but since these areas are exposed to maceration and surface contamination, recovery from irradiation is slow and such areas are susceptible to recurrent ulcerations.

The skin of the vulva is particularly susceptible to chronic painful ulceration after radiotherapy.^{2,12} Excision and electrosurgical removal of resectable cancer of the vulva saves time and trouble for doctor and patient. The ulcerated superficial carcinoma associated with leukoplakia is

minimal loss of organ tissue. Circumcision through reduction of maceration and infection lowers the incidence of trophic ulcer. In the event of recurrent ulceration after adequate radiotherapy, biopsy and electrocoagulation or excision and approximation is advised, since the lesion is most probably a trophic ulcer.

Carcinoma of the anus with infiltration of musculature has been treated by low intensity radium needles and intraluminary radium rather than by resection in



FIG. 13. Case x. N. B., physician, aged 26. Elective, precautionary application of pedicle flap to forearm after 8,000 gamma r of radium and 1,600 r in tissue of 180 kv. (constant) roentgen therapy during three weeks for postoperative residual fibrosarcoma in 1942. No recurrence and skin of near normal consistency four years later.

some cases in order to preserve sphincteric function. Healing has been slow with delayed recurrent ulceration. Surface closure can be accomplished by excision and approximation with a sliding flap for relief of tension.

CARCINOMA OF SKIN LARGER THAN 5 CM.

In spite of usually good tolerance of well vascularized skin (see Case VIII)²⁰ an excessively large lesion may so deplete the regenerative capacity of tissue that grafting may be necessary. In Case VII closure of the extending ulceration by a sliding flap stopped recurrent extending necrosis and preserved the impaired and exposed facial nerve. Although the skin of the neck tolerates intensive radiotherapy well, delayed healing or recurrent ulceration occurs at times from blistering sunburn, from scratching or rubbing of the skin by a tight or stiffly starched collar. A patient recovering from radiodermatitis of neck should wear his collar soft and loose.

SARCOMATA

The eradication of fibrosarcoma requires administration of 7 to 10 threshold erythema doses, which when delivered into large areas of the skin may lead to persistent or recurrent ulceration with necrosis

of the underlying subcutaneous tissues. Interstitial radium combined with deep roentgen therapy in this dosage has been effective in the control of five sarcomata persistent after resection and deep roentgen therapy. The large size of lesions and devascularization by previous surgery and irradiation required application of grafts for closure in 5 cases. In 3 cases grafting was delayed until considerable necrosis had occurred, while in 2 other cases precautionary grafting was elected eight weeks after completion of radiotherapy.

Osteogenic and periosteal fibrosarcoma of bone have been treated by intensive deep roentgen therapy, to be followed by amputation eight to twelve weeks later in case no metastatic lesions grew to obvious size during that interval. The program was agreed to in advance by the patient, family, surgeon and radiotherapist. In a few cases no viable neoplasm was found in multiple microscopic sections. In one case amputation was necessitated by ulceration and osteomyelitis developing two years after radiotherapy in a patient refusing amputation originally. Pathological fracture with non-union has been met in another case five years after successful control of a fibrosarcoma of the thigh by intensive deep roentgen therapy.

ELECTIVE SURGICAL CLOSURE FOLLOWING INTENSIVE RADIOTHERAPY

Precautionary surgical closure of large intensively irradiated areas permits eradication of previously uncontrolled cancer. Closure of the irradiated area by unirradiated skin provides a more durable surface, which is more comfortable and tolerates trauma without hazard of ulceration or necrosis. In the case of a young physician, Case x, irradiated for postoperative residual fibrosarcoma of the forearm, a full thickness pedicle flap from the abdomen was applied following irradiation and block resection. In Case II, multiple small deep grafts were applied to a subsiding radiodermatitis of the buttock to prevent subsequent ulceration and necrosis, which seemed certain to eventuate after delivery of 12

T.E.D. during three weeks to a postoperative residual fibrosarcoma of the buttock. A large, free, thick split graft would have given more complete coverage and a better cosmetic result, but the multiple free grafts were easily applied, took well and covered the ulcerated area effectively. The grafted central area has good consistency and sensation, while the peripheral atrophic area has only subsistent vascularity and feels itchy and uncomfortable.

DISCUSSION

Trophic ulceration is to be anticipated occasionally following proper radiotherapeutic eradication of cancer from areas of only subsistent vascularity, marginal recuperability and depleted regenerative capacity. The low healing reserve of such tissues must be conserved by individualization of therapy with attention to all constitutional, regional and environmental, as well as radiotherapeutic, factors influencing wound repair.

The total effective dosage of radiation should be the smallest which will consistently and completely eradicate cancer. The space distribution must be so regulated as to deliver a cancericidal dosage throughout the neoplasm and yet with minimal irradiation of the adjacent uninvolved tissues of the tumor bed. Attenuation of intensity and protraction of fractionation, within reasonable limits, promotes the recovery of uninvolved tissues for comparable destruction of cancer. However, even with the best regulated therapy, ulceration will occur occasionally in regions which are deficient in blood supply, directly overlying bone and cartilage, exposed to maceration and infection, damaged by recurrent trauma or extensively involved by disease. The possible desirability of subsequent surgical repair is to be anticipated in such cases. Primary surgical excision may expedite the management of certain resectable lesions associated with infection of bone or cartilage or occurring in areas exposed to maceration, subject to excessive trauma, or lacking in subcutaneous tissue.

Radiotherapy was elected rather than

surgery for eradication of cancer in this reported series of cases for the following general reasons: (1) residual or recurrent neoplasm after previous surgical removal; (2) declared inoperability of lesion; (3) more certain eradication of lesion infiltrating underlying essential structures; (4) more preservation of adjacent healthy tissue; (5) probability of spontaneous healing; and, in that event (6) avoidance of hospitalization.

The weighing of probable benefits against possible hazards of irradiation, surgery and combined therapy call for an open mind, discerning judgment and courageous decision if the patient is to receive the most certain control of cancer with least subsequent disability.

SUMMARY

1. Chronic ulceration occurs following properly controlled radiotherapeutic eradication of cancer due to inadequate recuperability of tumor bed which may be (*a*) inherent from poor vascularity, malnutrition, and atrophy; (*b*) inhibited by trauma and infection with resulting necrosis; or (*c*) depleted by excessive demands of intensive therapy or extensive disease.

2. In a series of 33 cases, delayed or recurrent ulceration occurred one month to six years after initial healing in 22 cases, while in 11 cases ulceration persisted following irradiation.

3. The main factor contributing to recurrent ulceration was deficiency of blood supply due to (*a*) vessels being of small caliber and lacking deep collaterals (dorsum of hand, scalp), or (*b*) impoverishment of vascularity by previous surgery or irradiation. Ulceration resulted from infection introduced by sunburn, freezing or other trauma (lip, nose, ear, hand) and aggravated by maceration and contamination (vulva, penis, anus).

4. Chronic ulceration persisting after irradiation occurred only in case (*a*) the lesion was over 4 cm. across, or (*b*) complicated by exposure and infection of cartilage or bone.

5. The recuperability of tissues of mar-

ginal vitality must be promoted and conserved by proper nutrition, correction of anemia, conservation of regional blood supply, reduction of infection, avoidance of sunburn, freezing or other trauma. Radiation appears to conserve tissue repair when delivered at relatively low intensity, in fractionated dosage, with proper space distribution, and in dosage adequate to completely eradicate cancer by the first course of therapy. Surgical repair conserves recuperability.

6. The surgical technique of plastic repair, causes of failure and specific indications for the various procedures are presented in detail according to preparation of ulcer bed, and closure by (a) approximation, (b) sliding flap, (c) pedicle flap, (d) multiple small deep grafts, and (e) free split grafts.

7. The advantages of surgical repair in chronic ulceration occurring after irradiation are: (a) expeditious closure with prompt relief of pain and exclusion of infection, (b) elimination of necrotic tissue and prevention of further necrosis, (c) exclusion of residual neoplasm by microscopic examination, (d) closure by durable skin, with reduction of hazard of trauma and avoidance of malignant degeneration.

8. Surgical repair warrants consideration in the case of ulceration which fails to heal under good medical care, within three months after irradiation, or which is exposed to contamination and maceration, or is associated with infection of cartilage or bone.

9. The possible desirability of subsequent plastic repair is to be anticipated following the radiotherapeutic eradication of cancer in the case of (a) lesions over 5 cm. in diameter, (b) recurrent neoplasms previously irradiated, (c) lesions complicated by involvement of cartilage and bone; (d) lesions of the scalp, especially if over 2 cm. or fixed; (e) areas anatomically deficient in vascularity and exposed to excessive trauma; (f) areas exposed to maceration and contamination. Primary surgical resection with plastic closure warrants consideration in the initial planning of treatment in such cases.

10. Cancer was eradicated by radiotherapy rather than by surgery in this series of cases due to various reasons, such as declared inoperability, more certain eradication of infiltrating cancer, greater preservation of uninvolved tissues, and probability of spontaneous healing in most cases.

11. Precautionary surgical closure elected eight to twelve weeks following intensive radiotherapy (1) permits administration of higher total dosage for eradication of more radioresistant neoplasms, and also (2) allows elimination of larger neoplasms which so exhaust the inherent regenerative capacity of the area as to require grafting for closure.

12. Preliminary enlightenment of the cancer patient with reference to the nature of his disease, the probable response to treatment and the possible need for subsequent plastic repair develops an intelligent forbearance and cooperation which permits more adequate control of the cancer, better management of complications and avoidance of trouble and misunderstandings.

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REFERENCES

1. BERSON, M. I. *Atlas of Plastic Surgery*. Grune & Stratton, New York, 1947.
2. BERVEN, E. G. E. 177 Fälle mit primärem Vulvakarzinom. *Acta radiol.*, 1941, 22, 99-154.
3. BLAIR, V. P. Influence of mechanical pressure on wound healing. *Illinois Med. J.*, 1924, 46, 249-252.
4. BLAIR, V. P., & BROWN, J. B. Use and uses of large split-skin grafts of intermediate thickness. *Surg., Gynec. & Obst.*, 1929, 49, 82-97.
5. BLAIR, V. P., BROWN, J. B., and HAMM, W. G. Surgical treatment of post-radiation keratosis. *Radiology*, 1932, 19, 337-344.
6. BLAIR, V. P., MOORE, S., and BYARS, L. T. *Cancer of the Face and Mouth*. C. V. Mosby Co., St. Louis, 1941.
7. BRADDON, P. D. Treatment of carcinoma of the dorsum of the hand. *Med. J. Australia*, 1944, 1, 368-370.
8. BROWN, A. M. *Modern Plastic Surgical Prosthetics*. Grune & Stratton, New York, 1947.
9. CLARKE, C. D. *Facial and Body Prosthesis*. C. V. Mosby Co., St. Louis, 1945.

10. CONWAY, H. Surgical management of post-radiation scars and ulcers. *Surgery*, 1941, 10, 64-84.
11. COOPER, A. G. S., and ROBERTSON, D. F. Treatment of post-irradiation ulcers by radon ointment. *Med. J. Australia*, 1945, 1, 297-300.
12. COSBIE, W. G. Carcinoma of vulva. *Canad. M. A. J.*, 1940, 43, 439-444.
13. DALAND, E. M. Surgical treatment of post-irradiation necrosis. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1941, 46, 287-301.
14. DAVIS, J. S. The radical treatment of x-ray burns. *Ann. Surg.*, 1920, 72, 224-227.
15. DAVIS, J. S. The small deep graft. *Ann. Surg.*, 1930, 91, 633-635.
16. DRIVER, J. R., and COLE, H. N. Treatment of epithelioma of the skin of the ear. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 48, 66-73.
17. FIGI, F. A., NEW, G. B., and DIX, C. R. Radio-dermatitis of the head and neck with a discussion of its surgical treatment. *Surg., Gynec. & Obst.*, 1943, 77, 284-294.
18. GILLIES, H., and McINDOE, A. H. Plastic surgery in chronic radiodermatitis and radionecrosis. *Brit. J. Radiol.*, 1933, 6, 132-147.
19. GRAY, L. H., ELLIS, F., FAIRCHILD, G. C., and PATERSON, E. Dose-rate in radiotherapy; symposium. *Brit. J. Radiol.*, 1944, 17, 327-342.
20. HUNT, H. B. Treatment of large protruding carcinomas of the skin and lip by irradiation and surgery. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1940, 44, 254-264.
21. HUNT, H. B., and BREIT, D. H. Physiobiology and general management of chronic ulceration occurring after irradiation. *AM. J. ROENTGENOL. & RAD. THERAPY*, January, 1948, 59, 9-18.
22. KOLMER, J. A. Penicillin Therapy Including Streptomycin, Tyrothricin, and Other Antibiotic Therapy. D. Appleton-Century Co., New York, 1947.
23. LOW-BEER, B. V. A., and STONE, R. S. Treatment of late post-irradiation ulcers with radon ointment. *Radiology*, 1946, 46, 149-158.
24. MAGNUSON, A. H. W. Skin cancer. A clinical study with special reference to radium treatment. *Acta radiol.*, 1935, supp. 22, pp. 1-287.
25. MATTHEWS, D. N. The Surgery of Repair; Injuries and Burns. Oxford University Press, London, 1944.
26. MERRITT, E. A., and RATHBONE, R. R. Treatment of epithelioma involving cartilage using 220 K. V. P. and heavy filtration. *Radiology*, 1935, 24, 701-707.
27. MOHS, F. E. Chemosurgical treatment of cancer of the nose; microscopically controlled method. *Arch. Surg.*, 1946, 53, 327-344.
28. PADGETT, E. C. Calibrated intermediate skin grafts. *Surg., Gynec. & Obst.*, 1939, 69, 779-793.
29. ROBINSON, G. A., and HARRIS, J. H. Treatment of cancer of the skin of the nose. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 48, 59-65.
30. SCHREINER, B. F., and WEHR, W. H. Primary new growths involving the hand. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1934, 32, 516-523.
31. SMITHERS, D. W. Spatial distribution of x rays and total energy absorption. *Brit. J. Radiol.*, 1942, 15, 50-55.
32. TIDRICK, R. T., and WARNER, E. D. Fibrin fixation of skin transplants. *Surgery*, 1944, 15, 90-95.
33. TYLMAN, S. D., and PEYTON, F. A. Acrylics and Other Synthetic Resins Used in Dentistry. J. B. Lippincott Co., Philadelphia, 1946.
34. UHLMANN, E. Significance and management of radiation injuries. *Radiology*, 1942, 38, 445-452.
35. UHLMANN, E., and CROSSMAN, A. Use of radon ointment as a means of differentiation between radionecrosis and recurrent carcinoma. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 620-623.
36. VAN ROOJEN, J. Intensity of radiation and selective action. *Brit. J. Radiol.*, 1939, 12, 547-553.
37. YOUNG, F. and FAVATA, B. V. Fixation of skin grafts by thrombin-plasma adhesion. *Surgery*, 1944, 15, 378-386.

DISCUSSION

DR A. W. OUGHTERSON, New York, N. Y. It is now recognized by surgeons that most of the complications encountered in the healing of wounds can be prevented if they are anticipated and proper preventive precautions are carried out. These factors may be grouped under the four headings of nutrition, blood supply, infection, and trauma as has been done. Adequate evaluation of these factors plus the newer knowledge of techniques and dosage in radiation therapy have greatly reduced the risk of ulceration in radiation therapy of tumors. Prevention of such complications is therefore the most important measure.

Chronic ulceration, however, may occur if adequate preventive measures have not been taken. In the management of ulceration as in the preventive measures the same careful attention must be given to nutrition, blood supply, infection, and trauma, in addition to those factors peculiar to the particular lesion. A second type of ulceration is that which may be inherent in the location and extent of the tumor and the treatment which may be necessary. Such instances are those tumors closely associated with bone.

Subclinical nutritional deficiencies may be of the greatest importance when heavy irradiation is necessary. It is important to correct not only such coexisting diseases as diabetes and syphilis but anemia, vitamin deficiencies, hypoproteinemia, and electrolyte balance. It may be necessary to consider the albumin and globulin fractions rather than the total proteins alone.

Tissue injured by irradiation is especially susceptible to infection, hence portals of entry for bacteria must be carefully guarded. One of the most common errors is the extraction of teeth after they have been injured by irradiation with resulting infection and osteomyelitis. Here both trauma and infection are added insults in a bone whose blood supply has already been injured.

It is well to remember that no surgical operation is bacteriologically sterile and that bacteria are always present. These ordinarily cause no trouble in the presence of the normal body defense. However, when surgery is undertaken in tissue damaged by irradiation the risk of infection is a major problem. It should be remembered that the usual boiling of surgical instruments does not destroy anaerobes. These are ordinarily phagocytized but when the blood supply is impaired in the presence of heavy scar tissue this may not occur and a low grade infection results opening the area to further infection. It is safer to autoclave all material and instruments when operating in such an area. The avoidance of unnecessary surgical trauma is also of the greatest importance. When ulceration has occurred the margin between healing and continued ulceration may be very narrow. Success or failure to obtain healing may depend on infinite pains and attention to each detail in the healing process.

Dr. L. H. JORSTAD, St. Louis, Mo. I wish to congratulate Dr. Hunt and Dr. Breit on this constructive and timely presentation of a difficult, and too often not discussed subject. That "surgery and irradiation should be considered supplementary, rather than competitive in the treatment of cancer" is particularly applicable in the more advanced cases of cancer such as are illustrated in this paper. Not only is it desirable that the radiotherapist should be familiar with the methods, principles, and possibilities of surgical treatment of chronic ulceration, but the surgeon as well should be familiar with the

possibilities of irradiation in cancer, particularly in this group of cases.

I might add a general principle to those the authors have cited. I think it wise to delay major reconstructive procedures approximately one year following eradication of the extensive neoplasm, provided the functional disturbance due to the defect does not outweigh the possibility of recurrence of malignancy in the defect resultant from such eradication. This is predicated on the basis that the greater majority of recurrences occur within the first year. It discourages doctor and patient to find recurrence of malignancy in a reconstructed area of tissue.

Of course, the last paragraph and statement by the authors cites this whole problem; to wit, "The weighing of probable benefits against possible hazards of irradiation, surgery and combined therapy call for an open mind, discerning judgment and courageous decision if the patient is to receive the most certain control of cancer with the least subsequent disability." To this statement could be added "and the shortest period of disability with the minimum of discomfort."

DR. HUNT (closing). It is fitting that discussion on the subject of eradication of cancer with surgical repair of subsequent ulceration should be participated in by oncologists particularly experienced in the field of surgery. I wish to thank Dr. Oughterson for emphasizing that the fundamental processes interfering with the healing of ulceration after radiotherapy should be subjected to the same physiological analysis which is accorded ulceration following destructive agents. The problems of wound repair have received much attention in surgical literature and too little in radiological literature, considering that recovery from intensive radiotherapy always involves problems of wound repair. Also, I wish to thank Dr. Jorstad for emphasizing the desirability of generous collaboration between surgeons and radiotherapists in cancer therapy. We are inclined to apply grafts earlier than Dr. Jorstad advises, providing the dosage of radiotherapy has been adequate, ranging from 7 to 10 T.E.D., and that multiple biopsies from the ulcer base are free from cancer. The difficulties of repair become somewhat greater beyond three to six months following radiotherapy due to progressive endarteritis, fibrosis and chronic infection. Again I wish to thank Dr. Oughterson and Dr. Jorstad for their reassuring discussions.

RADIATION AND SURGICAL TRENDS IN THE TREATMENT OF CANCER OF THE CERVIX UTERI*†

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SELECTION of the subject here discussed is evidence of the greater interest which lately has fallen upon the use of surgery in the treatment of cancer of the uterine cervix. The possible trend away from the better established radiological methods is viewed by some with apprehension. It is feared that more general use of surgery will result in higher primary mortality as well as a fall in survival rates. Others look upon revival of radical hysterectomy as resuscitation of a method explored already and proved by experience to be less practical than the use of roentgen rays and radium. Another group, by no means small in number, is of the opinion that the best treatment for some patients may necessitate a combination of both surgery and radiation.

Proponents of radical hysterectomy are optimistic. By applying the many advances made in modern surgery, they have perfected their technique and proved in well selected patients that the primary mortality need be no higher for operation than for irradiation. They have emphasized the importance of selecting patients. It is not intended that surgery will replace established methods. In the treatment of certain selected groups, however, radical hysterectomy is presented as a challenge to irradiation. A provocative situation of that order can be a wholesome stimulus to clinical advance. That point is best exemplified in the well publicized work of Meigs,⁹ and there can be no doubt that he has advanced the technique of radical hysterectomy to the greatest perfection that has been attained. Upon that basis there is complete

justification for exploring again a procedure that once was almost entirely discarded. The operation has never been entirely abandoned, however, and interest has been supported by several individuals: notably, Bonney, of London, and Lynch, of California, and their respective associates. The modern approach to the problem is based upon experiences of these men, as well as experiences of others who have favored combinations of surgery and irradiation.

According to Berkeley and Bonney,⁴ abdominal hysterectomy for cervix cancer was first proposed in 1878 by Freund. Not before 1895, however, was the feasibility of radical operation demonstrated. The same year marked the discovery of x-rays by Röntgen. Possibilities for radical operation were demonstrated by Ries in work done on dogs and in cadavers. The following year Clark and Thring independently applied the operation to living patients. Wertheim produced the clinical data that fixed his name to the technical procedure. Schauta, Adler, and many others extended knowledge of surgical treatment and attempted various modifications of technique.

Coincident with the early but steady advances in surgery were the epoch-making developments in physics, chemistry, and biology that followed the discovery of roentgen rays and radium. Robert Abbe, of New York, was one of the early pioneers in applying radium to medicine. Burnam⁶ attributes to Wickham's visit to Baltimore in 1909 a stimulus to the work continued by Howard A. Kelley. A small amount of radium was then in use at Baltimore and

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† Presented before the Philadelphia Roentgen Ray Society, April 3, 1947.

they had observed a remarkable response in a patient with cervix cancer that reappeared after hysterectomy.

We of this generation may not fully appreciate the profound impressions gained in those early days from favorable responses in patients with completely hopeless prognoses. The degree of palliation must have been in sharp contrast to that which might have been expected from such commonly used methods as acetone treatment or actual cauterization. In more favorable cases the relative simplicity of treatment must have been in sharp contrast to the hazards of radical surgery.

Radiosensitivity as manifested by favorable clinical response was not the only factor in determining the adaptability of cervix cancer to irradiation. Accessibility of the lesion to palpation and visual inspection were equally as important. Difficulties encountered in attempting to eradicate the disease surgically are also to be considered. The method became firmly established by the work of such men as Henry Schmitz, Heyman, Bailey, Ward, Healy, and many others. It is not surprising that contributions to advance in radiation treatment were made by gynecologists as well as radiologists. Clinical results were of a quality that resulted in general agreement upon radiation as the method of choice for treatment of cervix cancer. The finality of that decision is well demonstrated in a letter written by H. S. Crossen⁷ and published in his textbook on operative gynecology.

Irradiation is, of course, not the complete answer to the treatment of cervix cancer. Successful treatment is not gained in all of the early lesions. That has been one point upon which has been based renewed interest in surgery. To better evaluate the treatment of cervix cancer, it is necessary to consider some of the biologic properties of the disease upon an anatomical and pathological basis.

Despite origin in the same organ or type of tissue, there are wide variations in the clinical behavior of cancer in different indi-

viduals. In some instances the neoplasm may remain localized for relatively long periods. In others there may be metastases that develop promptly. Neither size of the primary lesion nor duration of symptoms is an accurate indicator of the stage of clinical advance of cervix cancer. Extensive involvement can occur with only slight enlargement of the cervix. Some early cancers form bulky cervical tumors that almost fill the vagina. Patients applying for treatment immediately after the onset of suspicious symptoms may present well advanced cancers. In others the tumor may appear clinically to be localized to the cervix in spite of symptoms present for a substantial period. Those differences are due to variations in biologic properties responsible for infiltrating tendencies and circumstances prompting dispersion by other methods.

Taylor and Nathanson¹⁴ have published a classic study upon methods of spread of tumors. Direct infiltration of surrounding tissues takes place along fascial planes or between laminations of tissue. In cervix cancer the paths of least resistance to invasion extend laterally into the parametrial regions along the ligament of Mackenrodt at the base of the broad ligament. Infiltrations can extend in other directions including all of the paracervical tissues. Involvement of that order is more common in the anterior direction toward the bladder. Other points of extension include the sacrouterine ligaments and vaginal wall. In the latter instance, one finds occasional examples suggesting the possibility of transplant by contact.

Fascial planes between the cervix and the bladder and rectum inhibit direct invasion of those structures. Time required for tumor to traverse the few millimeters of distance to those organs is usually on the order of many months and sometimes years. The effectiveness of that barrier has caused Bonney⁴ to believe that an uninvolved margin of tissue only 1/20 inch in thickness is consistent with successful surgical removal. Infiltrations extending in other di-

rections, however, do not meet with the same obstruction. Invasion into the parametrium also enters a zone traversed by the majority of blood vessels, lymphatics, and nerves. It is by means of those structures that metastases can occur.

Vascular and lymphatic structures form a plexus about the uterus which converges near the junction of the corpus and cervix. Main pathways extend lateralward along the base of the broad ligaments. Lesser lymphatic connections are made with extensions along the vagina, chiefly in its anterior wall, that communicate with a plexus near the urethral orifice. A few variable trunks pass lateralward with the ovarian vessels, or follow the sacro-uterine ligaments to the chain of sacral and aortic nodes. As noted before, the early direct extensions of cancer of the cervix are into the paracervical tissues, and adjacent portions of the cardinal ligaments. It is in those regions that contact can be made with the principal lymphatic channels. One might expect nodes most frequently involved to be those following roughly the course of the uterine vessels.

In the primary group of nodes the more constant include the ureteral gland, located near the point of crossing of the ureter and uterine artery, nodes along the iliac vessels, those at the bifurcation of the common iliacs, and the obturator group situated in the obturator fossae. Secondary nodes are found along the common iliac and sacral vessels and the aorta. Inconstant nodes may be found adjacent to the cervix and upper vagina or near the bladder and rectum. Lymphatics that follow the ovarian vessels or sacro-uterine ligaments communicate with nodes of the secondary group in the common iliac and aortic chains or with the sacral group.

Data on lymph node involvement have come from findings at autopsy and at operation. Considerable attention has been focussed upon node involvement by those who have combined irradiation with surgical procedures such as iliac lymphadenectomy. That procedure was developed in

1930 by Taussig,¹³ but was also conceived independently by Leveuf.⁸ The cervix and uterus are irradiated in the attempt to simplify treatment and lessen the hazard of radical operation. Upon the assumption that the quantity of radiation reaching the regional nodes is inadequate for the destruction of tumor, those regions are treated surgically by the removal of lymphatic structures. The usual sequence is to begin treatment with roentgen rays. This is followed by iliac lymphadenectomy, and radium is then applied to the cervix.

Morton¹⁰ has pointed out the difficulty in obtaining accurate statistical information on lymph node involvement. He cites experiences of several authors. Among patients selected for radical hysterectomy, positive lymph node involvement is found in about half of those showing parametrial invasion. Positive lymph node involvement is found in about one-third, or less, of patients with the parametria microscopically free of cancer. Thickening of a parametrium may be only inflammatory, and a parametrium clinically free of invasion may contain microscopic deposits of tumor. It is obvious that findings at bimanual examination are not accurate for determining the probability for lymphatic dispersion. It can be assumed that a large percentage of patients have lymph node metastases when diagnosis is established. The first nodes most frequently involved include the obturator, hypogastric, ureteral, and sacral groups. More advanced involvement can extend to a second barrier in the lumbar and inguinal regions. The second group is involved only in advanced stages, and in not more than 5 or 10 per cent of patients does dispersion reach the second group without prior invasion of the first.

Berkeley and Bonney⁴ found lymph node involvement in 40 per cent of their patients treated by radical hysterectomy. The five year survival for that group was about half the rate for patients without demonstrable metastases. Taussig¹³ performed iliac lymphadenectomy chiefly in patients falling into the Stage II League of Nations

classification of clinical advance. More favorable lesions showed few positive glands. The operation was deemed impractical for more advanced cases. The nodes most commonly involved in the order of frequency were the hypogastric, obturator, ureteral, and external iliac. Of 70 patients observed for more than five years, the incidence of glandular involvement was 33 per cent. As noted by Bonney, the survival rate for patients without positive nodes was more than twice as good as that for individuals with lymphatic dispersion.

The rationale of surgery is based upon the fact that cancer beginning in the cervix remains for a variable period as a process localized within the immediately adjacent tissues. Dispersions beyond margins of direct infiltration may not necessarily preclude surgical cure. Radical hysterectomy includes removal of all nodes in the primary group as well as those along the common iliac arteries in the secondary group. The parametrial tissues and vagina are excised as widely as possible. The node excision is not a block dissection on the order of that done in the axilla for breast cancer, but succeeds in removal of the accessible glands and interruption or resection of their communicating lymphatic vessels. The operation meets, therefore, the anatomical and pathological requirements for adequate treatment. It attempts also to meet surgically some of the biologic variations in tumor growth. Among cancers that undergo metastasis promptly after onset of the disease, there is a possibility that early dispersions will be trapped in the nodes removed. Efficiency of the procedure is dependent upon the completeness of local removal and the fixed regularity at which early dispersions will follow and remain within passageways brought into the operative field. Survival rates for radical hysterectomy show that the tumor is often confined within the volume of the tissue removed. The incidence of recurrence, on the other hand, indicates the frequency with which extension or dispersion occurred outside that volume.

Berkeley and Bonney⁴ report that 65 per cent of all recurrences appear within two years after operation. Ninety per cent of the total appeared by the end of the fifth postoperative year. Of considerable significance is the fact that they have not experienced a single recurrence after the tenth year. The location of reappearing cancer varied in different patients. One-fourth were located in the lower pelvis, including the vagina, bladder, and rectum. Approximately half were in the upper pelvis, including cellular tissue lateral to the uterus and bone. Less than one-fifth were behind the peritoneum in the abdomen and in the vertebrae. From these data it seems likely that some recurrences result from undetected extensions beyond margins of recognized infiltration, but that the majority are derived from dispersions beyond the zone of operative removal.

Bonney⁵ reports an operability rate of 63 per cent on 112 patients with cancer of the cervix seen at Middlesex Hospital and Chelsea Hospital for Women between 1907 and 1911. From that time onward, there were others who also determined methods of treatment for patients examined at those hospitals. Bonney has used the operability value of 63 per cent to estimate the total number of patients he may have seen for selecting his operable material. It is noted, however, that among his private patients the operability rate was about 80 per cent.

Between 1907 and 1936 Bonney treated surgically a total of 500 patients. During that period it is reckoned that consultation was performed upon approximately 800 patients. There were 70 postoperative deaths, making a primary mortality of 14 per cent. The mortality was highest in the early years, and for the last 200 patients, it was only 11 per cent. The operative mortality was greatest among those with more advanced lesions.

The clinical results reported by Bonney show for the 500 patients treated surgically a five year survival rate of 40 per cent. There were 300 patients in whom no lymphatic dispersions were demonstrable. Of

that number 53 per cent were well at the end of five years. Definite lymph node involvement was found in 200 patients, of whom 22 per cent survived the same period.

A comparison of surgical results with those obtained from irradiation can be made only on the basis of a uniform type of clinical material. One method for study is utilization of all patients as they are received in a given series. By that means the average result obtained for irradiation in one clinic can be compared with the average result obtained at another, in which operable patients are treated surgically and irradiation alone used only for the more advanced tumors. A comparison can also be made by deleting the advanced cases, and selecting from irradiation results only those statistics pertaining to operable tumors. The first method is to be preferred, but in the case of Bonney's data, such a comparison is not possible. In attempting the second method one finds the work of Pitts and Waterman well suited to such a study. Due to the fact that they have followed the Schmitz classification for cancer of the cervix, it is possible to select with reasonable accuracy the operable material from published results. Statistical data are available on a large series of patients, and for many years they have followed a particular technique using low intensity radium needles. Of some interest in comparing their data with surgical results is the fact that they are gynecologists.

The most recent publication by Waterman and his associates¹⁶ gives absolute statistics upon 579 patients treated between 1926 and 1940. In Stage I (Schmitz) the five year survival rate was 78.2 per cent. For Stage II it was 59.2 per cent. These two groups represented one-third (34 per cent) of the total series, and together showed a survival rate of 61 per cent. For Stage III, the five year value was 28.1 per cent. If Stages I, II, and III are grouped together, then three-fourths (76 per cent) of the total series is included. For that number 43 per cent survived the five year period. The absolute value for the

total of 579 patients was 33.3 per cent.

Data for comparing results are given in Table I. The 500 patients reported by Bonney are shown as 63 per cent of his total series. Survival rates in that group can be compared with clinical results in 76 per cent of Waterman's series if Stages I, II, and III (Schmitz) are included. On that basis, the five year survival rates are 40 per cent for surgery and 43 per cent for irradiation. The 300 patients without demonstrable metastases represented 37.5 per

TABLE I
CLINICAL STATISTICS REPORTED BY BONNEY AND BY WATERMAN. A COMPARISON OF SURGICAL AND IRRADIATION RESULTS IN SPECIFIED PERCENTAGES OF TOTAL CLINICAL MATERIAL

	Classification	Per Cent Total	Five Year Survival Per Cent
Bonney 800 patients	Operable 500 patients	63	40
	Negative nodes 300 patients	37	53
	Positive nodes 200 patients	25	22
Waterman 579 patients	Schmitz Stages I, II, III 442 patients	76	43
	Stage I, II 197 patients	34	61
	Stage III 245 patients	42	28

cent of Bonney's total of 800 patients. Among those there was a five year survival of 53 per cent. Stages I and II (Schmitz) represented 34 per cent of Waterman's series. Those patients may be assumed to have been relatively free of lymph node metastases, and 61 per cent survived the five year period. The 200 patients with positive nodes in Bonney's series represented one-fourth of his entire series. Experience in that group might be expected to

parallel roughly the results obtained in Stage III (Schmitz), which included 42.3 per cent of Waterman's series. In those patients the five year survival rate for surgery was 22 per cent, and for irradiation 28.1 per cent.

Comparison should be made also with the results reported by Meigs.⁹ Patients for surgical treatment have been selected carefully from among those with early lesions. An operability rate on the order of 10 to 15 per cent is anticipated. The reasons for choosing surgery in the treatment of those patients are based upon his experi-

at the end of a three year period. In Waterman's report the results for 1936 to 1940 were given separately to show advance in clinical work. For those years, Stages I and II represented 31 per cent of the clinical material. Among that number the five year survival was 71 per cent. That comparison can be seen in Table II.

On the basis of statistics that have been compared, there is not shown for surgery any marked superiority in clinical results. One of the important reasons given for surgery is that by removal there may be eradication of lymphatic dispersions which

TABLE II

CLINICAL STATISTICS REPORTED BY MEIGS AND BY WATERMAN. A COMPARISON OF SURGICAL AND IRRADIATION RESULTS IN SPECIFIED PERCENTAGES OF TOTAL CLINICAL MATERIAL.

	Classification	Number of Patients	Three Year Survival Per Cent	Five Year Survival Per Cent
Meigs	Operability 10-15 per cent	36	77.7	
Waterman	Stage I, II (Schmitz) 31 per cent	62		71

ences with certain early tumors found to be resistant to radiation. Hysterectomy eliminates the cervix as a potential focus of recurrence. Lesser amounts of damage to bowel are to be expected for surgical treatment. Finally, Meigs believes that tumor dispersions to lymph nodes cannot be destroyed by irradiation. By the end of 1945 radical hysterectomy had been done upon 91 patients without a single operative death. Thirty-six patients had been followed for a period of three years, with a survival rate of 77.7 per cent. Upon the basis of Bonney's work, one might expect that approximately 80 per cent of the recurrences to be expected would have occurred by the end of the third year. Due to Meigs' careful selection of patients, however, it is quite possible that an even greater percentage of the total recurrence rate will have developed by that time. For that reason his five year end results may not be particularly different for those found

might not be destroyed by irradiation. Lymph node metastases affect adversely the prognosis in cancer of the cervix. Among patients with node involvement proved by radical hysterectomy or iliac lymphadenectomy, the survival rates are only half those obtained in patients without demonstrable metastases. In Bonney's experience 60 of every 100 operable cases were without positive nodes. He contends, therefore, that survival rates of 60 per cent must be shown for irradiation before that procedure can be considered practical for those patients. That point in question is not so easily determined due to the fact that it is impossible to predict on clinical examination the exact status of regional nodes. If, on the other hand, one considers Stages I and II (Schmitz) as representing operable material, then the value stipulated by Bonney is exceeded in statistics reported by Waterman.

Taussig¹³ compared results among 70

iliac lymphadenectomies with 118 Stage II (League of Nations) patients treated during the same period with radiation alone. The five year survival for patients with gland dissection was 38.6 per cent. For radiation alone the value was 22.9 per cent. He commented upon advance in methods of radiation treatment, and anticipated an improvement in results. Of considerable significance is the fact that by including more recently treated patients not then observed for a period of five years, there was noted a decrease in the incidence of positive nodes. The value among his first 70 patients was 33 per cent. For his entire series the incidence was 26.8 per cent. Effect of irradiation on lymph node involvement is shown also in the detailed study made by Morton.¹⁰ Among his patients treated by iliac lymphadenectomy or radical hysterectomy 39.3 per cent showed positive nodes. Following the use of preoperative irradiation the incidence dropped to 11.4 per cent. Those experiences establish for irradiation a definite effect upon tumor in the regional nodes.

Neither Morton nor Taussig was able to demonstrate in tissues removed at iliac lymphadenectomy any constant histopathologic changes attributable to radiation effect. The fall in incidence of positive nodes after preoperative irradiation may not represent permanent destruction of cancer. The effects of roentgen rays applied through pelvic fields have been studied by repeated biopsies taken from the cervix.¹ Marked changes occur, but even in the few that show clinical disappearance of tumor, the effect is only temporary. Additional treatment by radium is necessary for permanent destruction of the lesion. It is obvious, therefore, that external irradiation alone is not apt to control tumor in lymph nodes. The contribution from radium to regional tumor-bearing points varies with the amount and technique of treatment.² Nolan and Quimby¹² have shown by calculation that a better distribution of radiation is obtained by combining intrauterine tandems with interstitial sources introduced into parametrial and paracervical tissues.

The use of low intensity radium needles is undoubtedly an important factor in the excellent clinical results obtained by Pitts and Waterman. From data on lymphatic involvement, there can be no doubt that some survivals after irradiation occur in patients with positive nodes.

There is no reason for viewing with apprehension the greater interest being manifested in surgery for the treatment of cancer of the cervix. Further exploration is justified on the basis of advance that has been made in operative procedures. The use of surgery in conjunction with radiation treatment is also important for accumulating data upon the changes produced by roentgen rays and radium on lymph node metastases. Nathanson¹¹ has recently described an extraperitoneal approach to iliac lymphadenectomy that may simplify the operation and increase the number of nodes accessible to removal.

It is well known that some cervix cancers display surprising resistance to irradiation despite the presence of rather favorable stages of clinical advance. There is no method for predicting accurately the degree of radiosensitivity to be expected for a given tumor. It is possible that classification made on the basis of gross characteristics of the tumor may be of value. Cervix cancers can be divided into infiltrating and everted types.³ By correlating gross appearance with histopathologic type, and estimations of tumor age with duration of clinical symptoms, methods may be devised for better evaluation of biologic properties. Those researches should also be correlated with data on lymph node metastases. It is not improbable that certain infiltrating types will be found to have biologic properties for which radical hysterectomy will be a valuable adjunct in treatment.

Despite the fact that a rising trend in surgery need not be viewed with apprehension, mention of risks involved cannot be escaped. Over-popularization of radical hysterectomy can result in injudicious use of the operation. Meigs has emphasized the

task involved in perfecting technique for radical hysterectomy. It should also be pointed out that knowledge of surgery alone is not adequate for the care of patients with cervix cancer. There must be knowledge of radiation effects and the biologic properties of tumor growth. Adequate treatment is particularly important in the more favorable stages of clinical advance due to the possibility for good results in that group. If thought is directed toward care of patients over a wide geographical area, it is more practical to populate regions with talent for satisfactory radiation treatment. Upon that basis there is strong argument for adherence to better established radiological methods.

It is not to be implied that radiation treatment is a simple procedure without hazard. There is risk in under-exposure and in over-irradiation. Inadequate treatment results in persistent tumor more resistant to radiation. Over-exposure can produce untoward sequelae by damage to normal tissues. There may be severe injury to the bowel and the bladder. Importance of the tumor bed as a normal structure is often neglected in clinical practice. Tod¹⁵ has described "supralethal" effects of radiation in which destruction of the tumor bed can result in uncontrolled growth of cancer by removal of normal inhibitory mechanisms. Responses of that order are sometimes incorrectly interpreted as evidence of marked resistance to radiation. It is not unreasonable to believe that the average treatment employed for cervix cancer has produced favorable results in spite of over-exposure. The normal tissues in question seem to have a relatively high tolerance to damaging effects of radiation. Average methods of treatment, however, cannot be expected to equal the clinical results that have been quoted for comparing radiological and surgical statistics. Neither can the surgeon with only occasional opportunity for performing radical hysterectomy expect to equal results obtained by those particularly skilled in the procedure. A point of value, perhaps unanticipated in the greater in-

terest in surgery, is the challenge radical hysterectomy presents in the treatment of early lesions. That provocative situation is stimulating. Advance in radiology has equalled in importance that made in surgery. It is essential that knowledge of that advance be more generally applied in clinical practice. It is the duty of those who combine radiation with surgery to produce knowledge of radiation effects on lymph node metastases. It is the duty of all of those who employ radiation to seek more data upon the biologic properties of tumor growth.

The author wishes to acknowledge his indebtedness to Dr. Mildred Trotter, Professor of Gross Anatomy, Washington University School of Medicine, for her assistance in the preparation of data on dispersion of cervix cancer.

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REFERENCES

1. ARNESON, A. N., and STEWART, F. W. Clinical and histologic changes produced in carcinoma of the cervix by different amounts of roentgen radiation. *Arch. Surg.*, 1935, 31, 542-567.
2. ARNESON, A. N. Distribution of radiation within the average female pelvis for different methods of applying radium to the cervix. *Radiology*, 1936, 27, 1-20.
3. ARNESON, A. N. Cancer of the Cervix: Principles of Radiation Treatment. In: *Progress in Gynecology*. Meigs, J. V., and Sturgis, S. H. Grune and Stratton, New York, 1946.
4. BERKELEY, C., and BONNEY, V. A Textbook of Gynecological Surgery. Fourth edition. Paul B. Hoeber, New York.
5. BONNEY, V. Results in 500 cases of Wertheim's operation for carcinoma of the cervix. *J. Obst. & Gynaec. Brit. Emp.*, 1941, 48, 421-435.
6. BURNAM, C. F. Early experiences with radium. Janeway Memorial Lecture. *Am. J. ROENTGENOL. & RAD. THERAPY*, 1936, 36, 437-452.
7. CROSSEN, H. S., and CROSSEN, R. J. *Operative Gynecology*. Fifth edition. C. V. Mosby, St. Louis, 1938.
8. LEVEUF, J., and GODARD, H. L'exérèse chirurgicale des ganglions pelviens complément de la curiethérapie des cancers du col de l'utérus. *J. de chir.*, 1934, 43, 177-187.
9. MEIGS, J. V. Wertheim operation for carcinoma of cervix. *Am. J. Obst. & Gynec.*, 1945, 49, 542-553.
10. MORTON, D. G. Pelvic lymphadenectomy in

- treatment of cervical cancer. *Am. J. Obst. & Gynec.*, 1945, 49, 19-31.
11. NATHANSON, I. T. Extraperitoneal Iliac Lymphadenectomy in the Treatment of Cancer of the Cervix. In: *Progress in Gynecology*. Meigs, J. V., and Sturgis, S. H. Grune and Stratton, New York, 1946.
 12. NOLAN, J. F., and QUIMBY, E. H. Dosage calculation for various combinations of parametrial needles and intracervical tandems. *Radiology*, 1943, 40, 391-402.
 13. TAUSSIG, F. J. Iliac lymphadenectomy for group II cancer of the cervix. *Am. J. Obst. & Gynec.*, 1943, 45, 733-748.
 14. TAYLOR, G. W., and NATHANSON, I. T. *Lymph Node Metastases*. Oxford University Press, New York, 1942.
 15. TOD, M. D. *The Results of Radium and X-Ray Therapy in Malignant Disease*. Second Statistical Report from the Holt Radium Institute, Manchester. E. and S. Livingstone, Edinburgh, 1946.
 16. WATERMAN, G. W., DiLEONE, RALPH, and TRACY, ELLSWORTH. The use of long interstitial needles in treatment of cancer of the cervix. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1947, 57, 671-678.



DOSAGE DETERMINATION WITH RADIOACTIVE ISOTOPES

II. PRACTICAL CONSIDERATIONS IN THERAPY AND PROTECTION*

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INTRODUCTION

A KNOWLEDGE of radiation dosage from artificially radioactive substances deposited in tissue is important in applications of these materials to tracer studies, as well as in therapy. In employing tracers in humans, it is essential to know that the incidental irradiation does not exceed safe limits. In all tracer work it must be assured that the radiation itself does not affect the phenomenon being investigated. While this can actually be determined only by trial, a knowledge of the tissue doses involved is useful. In therapy the same considerations apply as in any other type of irradiation.

It is highly desirable to express these doses in terms of roentgens, since that unit is generally employed for the usual types of radiation therapy with x-rays and radium. In the case of x-rays, ionization measurements in phantoms give satisfactory dosage data. For radium and radon in sealed containers, extensive dosage tables have been calculated, based on an experimentally determined value of radiation from a standard point source. Similar methods would be applicable to any gamma ray emitting radioactive substance *enclosed in a sealed container and used in the same manner as radon.*

As commonly used, most radioisotopes are ingested or injected in soluble form and subsequently deposited with a greater or less degree of selectivity in various cells or organs. It is evident that neither measurements nor calculations of the types cited would be satisfactory under such condi-

tions. Nevertheless when the physical factors of half life and radiation energy, and the physiological factors of uptake and excretion are known, it is possible, in some cases at least, to make satisfactory estimates of tissue dosage.

The roentgen, as defined by international agreement, applies only to x- or gamma radiation; it can therefore be used for gamma ray emitting isotopes but not for radiation due to primary beta particles. (The roentgen is defined as "that quantity of x- or gamma radiation such that the associated corpuscular emission per 0.001293 gm of air, produces, in air, ions carrying 1 e.s.u. of quantity of electricity of either sign.")

On the other hand if the energy absorbed per gram of air per roentgen (~ 83 ergs) is made the unit of energy absorption for beta rays it is possible to establish a comparable basis for beta ray dosage. To be sure, in going from air to tissues certain corrections will have to be made because the energy absorption in tissue per roentgen exposure of x- and gamma rays depends on both tissue composition and radiation wavelength, but in practice, for soft tissues, these corrections are not very large. Hence it is possible to define an "*equivalent roentgen*" as "that amount of beta radiation which, under equilibrium conditions, releases in one gram of air as much energy as one roentgen of gamma rays." Since the accepted symbol for the roentgen is "r," it is convenient to designate the equivalent roentgen by "e.r." (This is essentially the same unit as the "rep" or "roentgen equivalent physical" of the Plutonium Project.)

* Presented at the Forty-eighth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., September 16-19, 1947.

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This paper is based in part on work done under contract N6 ORI-99 with the Office of Naval Research.

In the present paper, formulae expressing the relationship between radiation dose and isotope concentration are developed and their clinical applications discussed. Since it is felt that the mathematical derivations will be of less interest to many readers than the practical aspects, the paper has been divided into two parts. The development of formulae will be left to Part II. In Part I, some of the final expressions will be presented, together with tables containing a considerable amount of pertinent information. Examples of the applications of the formulae to specific isotopes and definite problems will also be given in this section.

PART I. PRACTICAL ASPECTS

I-A. Beta ray emitters. When a radioisotope emits only beta rays, the dose is essentially confined to the regions containing the material because the range of the beta particles in tissue is only a few mm.* The total dose D_β , in equivalent roentgens, due to the complete disintegration of a radioelement biologically stable and present in a uniform concentration of C microcuries per gram of tissue is (see Part II-A)

$$D_\beta = K_\beta C \text{ e.r.} \quad \text{I}$$

where

$$K_\beta = 88 \bar{E}_\beta T \text{ e.r. per } \mu\text{cd}\dagger/\text{gram} \quad \text{Ia}$$

T is the half life of the isotope in days and \bar{E}_β the average energy per disintegration of the beta rays in million electron volts (Mev).

Doses per hour and per day are respectively

$$\begin{aligned} d_\beta (\text{hour}) &= D_\beta f_h \\ d_\beta (\text{day}) &= D_\beta f_d \end{aligned} \quad \text{II}$$

where f_d and f_h are the fractions of the entire quantity of the isotope which disinte-

grate per hour or per day respectively. Values of T , \bar{E}_β , K_β and f_d are given in Table I which refers to beta ray emitters. Z is the atomic number and A the atomic weight of the elements given in the first column. The last column gives the ranges in water for the most energetic beta particles of each beta ray spectrum for the different isotopes. Detailed discussion of this table will be given below. It should be noted that the column for K_β gives immediately the dose in equivalent roentgens for each microcurie completely disintegrating within a gram of tissue.

I-B. Gamma ray emitters. When a substance is a gamma ray emitter, the problem of dosage determination is more complicated. The rays released in a given gram of tissue produce only a small amount of ionization there; most of their energy is expended elsewhere along their paths. The problem becomes somewhat analogous to that of interstitial radium gamma ray dosage, except that instead of discrete sources one is confronted with extended ones.

The total dose D_γ due to gamma rays emitted by the complete disintegration of a radioelement biologically stable and present in a uniform concentration of C microcuries per gram of tissue is given by (see Part II-B).

$$D_\gamma = K_\gamma C g \text{ roentgens} \quad \text{III}$$

where

$$K_\gamma = 1.44 t I_\gamma \times 10^{-3}. \quad \text{IIIa}$$

The dose delivered in one day is

$$d_\gamma (\text{day}) = D_\gamma f_d \quad \text{IV}$$

f_d having the meaning expressed above. K_γ expresses the number of roentgens at 1 cm distance in air due to the complete disintegration of an unfiltered point source of one microcurie; $1.44 \times t$ is the average life in hours, I_γ the dose-rate in roentgens per hour at 1 cm in air from an unfiltered point source of 1 mc. The quantity g in equation III is a geometrical factor depending on the size and shape of the tissue mass under con-

* Many organs in small animals used in experiments dealing with isotopes emitting high energy beta-rays are not small in comparison to the range of the beta particles. Proper estimate of the dose in these instances is, in general very complicated, and must be left to the future.

† μcd .—microcuries destroyed, i.e., microcuries remaining in the tissue until completely disintegrated.

TABLE I

Physical data pertaining to calculations of radiation dosage resulting from beta rays and/or very soft x-ray radiation. The values of K_β and S_β are based on uniform and biologically stable concentrations of radioelements distributed in tissues of linear dimension large as compared to the range of the beta particles. The sign "o" under the heading "Radiation" indicates the absence of nuclear gamma rays.

\bar{E}_β is the average energy per disintegration.

$K_\beta = 88\bar{E}_\beta T$ is the radiation dose expressed in equivalent roentgens due to beta rays emitted during the complete disintegration of $1\mu\text{c}$ of radioelement per gram of tissue.

$f_d = (1 - e^{-0.693/T})$ is the fraction of the entire quantity of isotope which disintegrates in 24 hours.

$S_\beta = \frac{0.1}{K_\beta \times f_d}$ is the concentration of radioisotope expressed in $\mu\text{c}/\text{kg}$ which will deliver a dose of 0.1 e.r. to tissue during the first 24 hours of exposure.

Element	Z	A	Radiation	T Half life in days	\bar{E}_β (MeV)	K_β e r./ μcd per gram	f_d fraction disintegr. per day	S_β μc per kg	Weight per mc in 10^{-3} gram	Maximum range in water (mm)
Group A: \bar{E}_β is known to an accuracy of a few per cent										
C	6	11	β^+, o	0.014	0.380	0.47	1.0	213	0.0012	4.2
N	7	13	β^+, o	0.007	0.475	0.29	1.0	345	0.0007	5.6
Na	11	22	β^+, γ	1100	0.235	22000	$6.3 \cdot 10^{-4}$	7.3	197	2.1
		24	β^-, γ	0.61	0.540	29	0.68	5.1	0.113	6.4
P	15	32	β^-, o	14.5	0.605	885	0.047	2.4	3.6	8.0
Cl	17	38	β^-, γ	0.026	1.390	3.2	1.0	31	0.0076	27
K	19	42	β^-, γ	0.515	1.395	63	0.74	2.1	0.167	19
Sc	21	46	β^-, γ	85	1.117	870	0.008	14.3	30	1.0
V	23	48	β^+, K, γ	16	0.175	245	0.042	9.7	5.9	2.8
Mn	25	52	β^+, K, γ	6.5	0.085	48	0.101	20.6	2.6	2.2
		56	β^-, γ	0.108	0.890	8.5	0.998	11.8	0.046	14
Fe	26	59	β^+, γ	47	0.120	496	0.015	13.4	21.3	1.5
Co	27	56	β^+, γ	85	0.655	4900	0.008	2.6	36.6	7.0
		60	β^-, γ	1940	0.099	17000	$3.6 \cdot 10^{-4}$	16.5	895	0.8
Cu	29	61	β^+, K, o	0.142	0.433	5.4	0.992	18.7	0.067	5.5
		64	β^+, β^-, K, o	0.53	0.120	5.6	0.73	24.4	0.26	2.6
Zn	30	63	β^-, K, γ	0.027	0.965	2.3	1.0	43.5	0.013	12
As	33	76	β^-, γ	1.12	1.170	115	0.46	1.9	0.655	15.7
Br	35	82	β^-, γ	1.5	0.150	20	0.37	13.5	0.95	1.6
In	49	114	$\beta^-, (\gamma)$	50	0.940	4150	0.014	1.7	44	9.4
I	53	130	β^-, γ	0.525	0.270	12.4	0.73	11.0	0.53	4.5
		131	β^-, γ	8.0	0.205	144	0.083	8.3	8.1	2.2
RaE	83	210	β^-, o	4.85	0.330	141	0.133	5.3	7.85	5.2

Group B: \bar{E}_β is less accurately known than \bar{E}_β in Group A

C	6	14	β^-, o	$1.7 \cdot 10^6$	0.05	$8 \cdot 10^6$	$4 \cdot 10^{-7}$	32	$18 \cdot 10^4$	0.24
S	16	35	β^-, o	88	0.055	420	0.0079	30	24	0.2
Ca	20	45	$\beta^-, (?)$	180	0.10	1580	0.0039	16	62	0.8
Sr	38	89	β^-, o	55	0.57	2760	0.013	3	38	7
		90	β^-, o	9000	0.22	$17 \cdot 10^4$	$8 \cdot 10^{-5}$	6200		2.2
Y	39	90	β^-, o	2.6	0.90	200	0.24	2	18	11
Sb	51	124	β^-, γ	60	0.66	3480	0.012	2.4	57	12.3
I	53	128	β^-, γ	0.017	0.77	1.2	1.0	87	0.017	9.8
Au	79	198	β^-, γ	2.7	0.32	76	0.23	5.7	4.1	3.8

Group C: \bar{E}_β includes the total localized x-radiation following decay by electron capture

Mn	25	54	K, γ	310	0.0054	147	0.0022	340	128	
Fe	26	55	K, γ	1500	0.0059	780	$4.6 \cdot 10^{-4}$	280	633	
Co	27	58	β^+, K, γ	65	0.035	20	0.012	415	29	1.5
Zn	30	65	β^+, K, γ	250	0.01	180	0.003	185	124	1.2

Group D: \bar{E}_β consists of part of the radiation released in the decay by electron capture

Y	39	86	K, γ	105	0.005	46	0.007	310	69	
In	49	111	K, γ	2.7	0.0058	1.4	0.23	310	2.3	0.01

sideration and on the absorption of the gamma rays; in dosage tables for interstitial radium a factor analogous to g is implicit. For radon filtered by 0.5 mm Pt, I_γ in equation IIIa would correspond to the well known figure of 8.4 r per mc-hr (or mr/ μc -hr) at 1 cm distance in air, and

$K_\gamma = 133 \times 8.4 \times 10^{-3} = 1.1$ r per μcd . The values of I_γ and K_γ together with other pertinent information for gamma ray emitting radioisotopes are given in Table II.

I-C. Safe tracer concentration. In the main Tables I and II are self explanatory. Attention should be directed to column 7 in

TABLE II

Physical data pertaining to calculations of radiation dosage resulting from gamma rays. The sign "o" under the heading "Radiation" indicates the absence of nuclear gamma rays. The column headed "Annihilation Radiation" refers to positron-electron recombination, the column headed "Nuclear Gamma Radiation" refers to gamma rays originating in the disintegrated nucleus. The numbers in parentheses indicate the number of photons of the particular energy that are released per disintegration. In Group B, the numbers in square brackets pertain to x-ray emission following electron capture.

I_γ is the exposure in roentgens at 1 cm distance in air from an unfiltered point source of 1 mc, for one hour; or milli-roentgens per microcurie-hour (see formula XIV).
 $K_\gamma = 1.44 I_\gamma \times 10^{-3}$ is the number of roentgens at 1 cm distance in air from an unfiltered point source, per microcurie destroyed.
 $f_d = (1 - e^{-0.693/T})$ is the fraction of the entire quantity of isotope which disintegrates in 24 hours. (T is the half life in days.)

Element	Z	A	Radiation	Half life in hours	E _γ in Mev		I _γ at 1 cm. mr/μc-hr r/mc-hr	K _γ at 1 cm r/μcd	f _d fraction disintegr. per day	
					Annihilation radiation	Nuclear gamma radiation				
Group A: elements not decaying by electron capture, or x-ray emission following electron capture so soft that it can be treated like beta radiation and hence making no significant contribution to I _γ										
C	6	11	β ⁺ , o	0.33	0.511(2)		6.2	0.003	1.0	
N	7	13	β ⁺ , o	0.17	0.511(2)		6.2	0.0015	1.0	
Na	11	22	β ⁺ , γ	26500	0.511(2)	1.30(1)	13.2	500	6.3 · 10 ⁻¹	
		24	β ⁺ , γ	14.7		1.38(1)	19.1	0.40	0.68	
Cl	17	38	β ⁺ , γ	0.62		1.6(0.36)	7.6	0.0068	1.0	
K	19	42	β ⁺ , γ	12.4		1.51(0.25)	1.95	0.035	0.74	
Sc	21	46	β ⁺ , γ	2040		0.90(1)	11.4	33.5	0.008	
V	23	48	β ⁺ , K, γ	381	0.511(1.16)	0.98(1)	16.3	9.0	0.042	
Mn	25	52	β ⁺ , K, γ	156	0.511(0.7)	0.736(1)	10.5	4.4	0.101	
		56	β ⁺ , γ	2.59		1.77(0.3)	9.4	0.035	0.998	
Fe	26	59	β ⁺ , γ	1128		1.1(0.5)	6.55	10.7	0.015	
Co	27	56	β ⁺ , γ	2040	0.511(2)	0.845(1)	17.95	37.2	0.008	
		60	β ⁺ , γ	46500		1.16(1)	13.5	900	3.6 · 10 ⁻¹	
Cu	29	61	β ⁺ , K, o	3.4	0.511(1.56)		4.8	0.024	0.992	
		64	β ⁺ , β ⁺ , K, o	12.8	0.511(0.38)		1.2	0.022	0.73	
Zn	30	63	β ⁺ , K, γ	0.65	0.511(1.96)	0.96(0.09)	1.90(0.04)	0.0065	1.0	
As	33	76	β ⁺ , γ	26.8		0.55(0.37)	1.20(0.12)	0.083	0.46	
Br	35	82	β ⁺ , γ	36		0.547(1)	0.787(1)	0.79	0.37	
Sb	51	124	β ⁺ , γ	1440		0.6(1)	1.7(0.5)	16.4	0.012	
I	53	128	β ⁺ , γ	0.42		0.428(0.07)	0.2	0.00012	1.0	
		130	β ⁺ , γ	12.6		0.416(0.55)	0.537(1)	0.237	0.73	
		131	β ⁺ , γ	192		0.080(1)	0.367(1)	0.735	0.083	
Au	79	198	β ⁺ , γ	65		0.40(1)	2.4	0.22	0.23	
Group B: elements with x-ray emission following electron capture whose contribution to I _γ is not negligible										
Mn	25	54	K, γ	7450		0.835(1)	[0.0054(1)]	4.9 + [11]	52	0.0022
Fe	26	55	K, γ	36000		0.07(2 · 10 ⁻⁵)	[0.0059(1)]	[10]	—	4.6 · 10 ⁻⁴
Co	27	58	β ⁺ , K, γ	1560	0.511(0.3)	0.805(1)	[0.0064(0.85)]	5.7 + [7]	12.8	0.012
Zn	30	65	β ⁺ , K, γ	6000	0.511(0.03)	1.14(0.46)	[0.008(0.99)]	3.0 + [5]	26	0.003
Y	39	86	K, γ	2530		0.908(1)	[0.0142(1)]	14.4 + [3.1]	52.5 + [10.3]	0.007
In	49	111	K, γ	65		0.173(1)	[0.0231(1)]	2.3 + [1.4]	0.22 + [0.13]	0.23

Table I, headed S_β , which indicates the "safe tracer concentration," that is, the number of μc per kg of tissue weight which will result in a whole tissue dose of 0.1 r the first day, due to the beta rays alone. (The gamma ray contribution will be discussed below.) In the case of a short-lived element, the dose on succeeding days will quickly decrease to the vanishing point, while for long-lived substances it will continue at an appreciable level for some time.*

* This criterion of "safe dose" is decidedly conservative. One might prefer to choose such a level as 1 r in 10 days or some other value based on a longer period of time. This might avoid complications due to various half lives. However, the present familiar idea of safety is based on daily dose, hence that has been used

I-D. *Distribution of the radiation in tissue.*
The physical data presented enable the experimenter to calculate the actual dose delivered to a tissue or individual whenever the isotope concentration C is known as a function of time (see Part II-D). This depends on the amount of isotope administered, the species and metabolic state of the test animal, the mode of administration, the chemical form under which the radioelement is given, etc.

Physiological information of this nature here. It is not to be assumed that larger tracer doses should never be administered. It is sometimes entirely justifiable to use considerably higher doses in diagnostic problems.

is of great importance; the literature shows that a good deal of animal work has been done on the relative uptake of various isotopes by different tissues at different times. As an example, in Figure 1 are shown the relative radiation doses delivered in different tissues in mice injected intraperitoneally with P^{32} in the form of Na_2HPO_4 (16).

assuming uniform distribution. The "theoretical" whole animal dose* after complete disintegration of the isotope, was taken as 100 per cent, and all other tissue doses referred to this value. Thus at the end of three weeks, 64 per cent of the theoretical complete dose had been delivered; but all tissues tested, except the bone, had re-

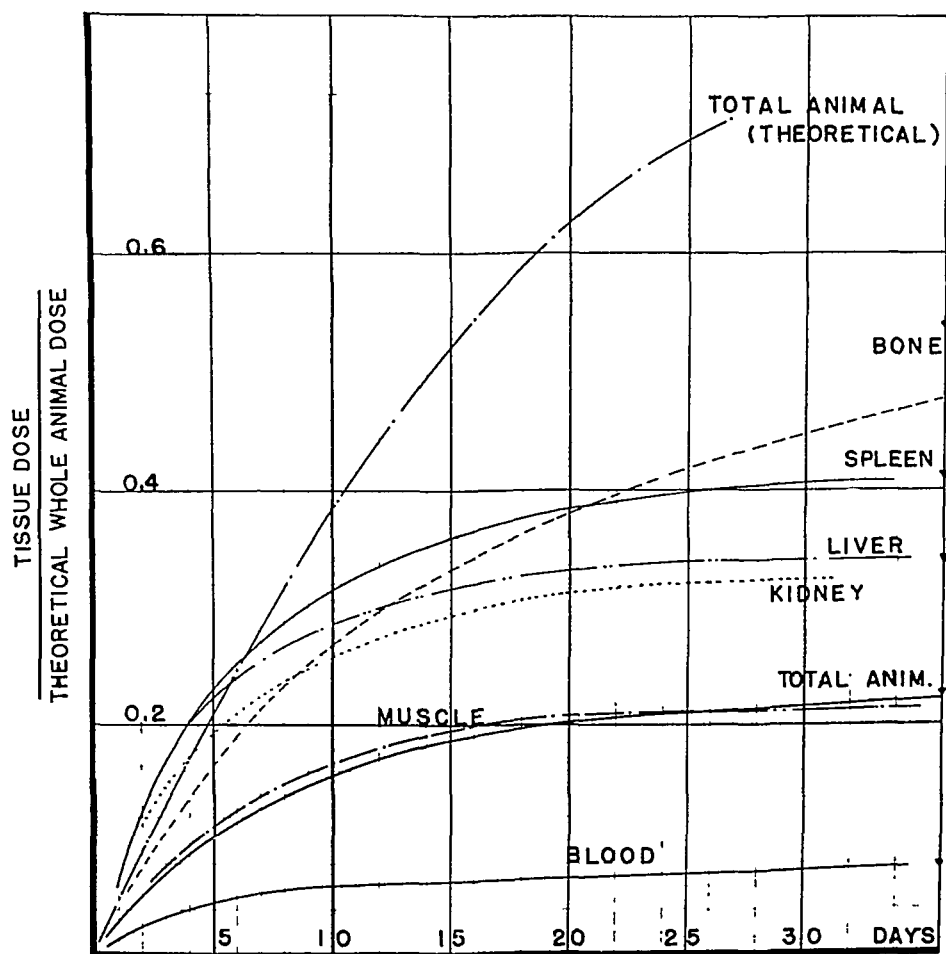


FIG. 1. Radiation dosage due to the beta-ray activity of P^{32} in different tissues in mice as a function of time. The points marked on the right margin are the actual tissue doses obtained by extrapolation to infinite time. Theoretical whole animal dose equals K_β times the number of microcuries administered divided by the total weight of the animal.

The animals were sacrificed at various times after the administration of the material, and the concentration of P^{32} was determined for the various tissues and organs. With this information it was possible to calculate the dose of radiation received by each tissue as a function of time. Similar calculations were made for the whole body

ceived already practically all their radiation because most P^{32} had disappeared. The liver, for example, had received about 33 per cent of the theoretical uniform dose. At

* By "theoretical" whole animal dose is meant the dose D_β which would have been obtained in the animal after complete disintegration of the isotope on the assumption of uniform concentration in the animal and of total lack of biological elimination.

that time the bone had received 39 per cent; but in the bone the dosage increased to 48 per cent at the end of 36 days.

No tissue actually attained the theoretical dose or would have attained it after longer periods of time because of biological elimination. From the curves, the actual tissue dosage per μc of P^{32} thus administered in a mouse of 25 grams can now be calculated. The total animal concentration would be $0.04 \mu\text{c}/\text{gram}$ and the "theoretical" total animal dose $D_\beta = K_\beta \times 0.04 = 885 \times 0.04 = 35.4 \text{ e.r.}$ (K_β from Table 1). The liver, then, at the end of three weeks would have received 33 per cent of this value or 12 r; similarly the bone at 36 days would have had $0.48 \times 35.4 = 17 \text{ r.}$

It is recognized that with P^{32} in mice these determinations are not as accurate as one would wish because the linear dimensions of most organs are smaller than the range of a considerable portion of the beta particles emitted by P^{32} . Similar information in larger animals would yield more reliable figures. Conversely this type of calculation would be fairly accurate even in a small animal, as the mouse, if soft beta ray emitters (H^3 , C^{14} , S^{35} , etc.) were used.

When working with humans it is not possible in general to study concentrations throughout the body and their variations with time by *in vivo* measurements; the extreme concentration of iodine in the thyroid is an exception. For most isotopes information must be obtained from biopsy and autopsy measurements and hence the data are meager; moreover they are scattered through various publications which were often not prepared with this point in mind. Accordingly it has happened too often that the published results lack some essential fact, such as the actual weight of the individual. It is to be hoped that more of this information will be forthcoming. In the meanwhile, it is wise to adopt a conservative attitude in dealing with humans whenever physiological information is lacking. This can be done by assuming that no biological elimination takes place.

I-E. Differential absorption ratio. To take

into account the differences in uptake which lead to differences in dose for the various tissues, it is convenient to express the concentration in terms of a "differential absorption ratio" (D.A.R.). For any tissue, this is the ratio of concentration of an isotope in that tissue to the average concentration in the body (neglecting excretion). Thus under the assumption just made if a particular tissue has a D.A.R. of 1, it receives the same dose of radiation as the average of the whole body. On the other hand, if it has a D.A.R. of 10, it receives ten times as much radiation as the average.

In calculating the safe doses for tracers, it is highly desirable to have some idea of the *range of the D.A.R.'s*. The safe dose is assumed to be 0.1 r per day for the entire body; if a certain tissue has a D.A.R. of 10, it would have received 1 r while the rest of the body received 0.1 r. This might lead to undesirable irradiation of certain tissues or organs from a dose believed safe otherwise.

The procedure outlined above needs clarification. In general, single tissues and the whole body have different rates and modes of elimination, hence the tissue D.A.R. will vary with time. The question then arises as to the time at which D.A.R.'s have significance in determination of tissue dosage. Evidently the D.A.R. will be too low when taken too soon after the isotope administration because the concentrations have not yet stabilized. Likewise adoption of the D.A.R. after several half lives will have little or no significance because most of the isotope has disintegrated. One useful index, whenever the isotope reaches the body tissues through the circulatory system, could be the stabilization of the plasma concentration. No general rule, however, can be given and good judgment is of paramount importance.

I-F. Effective half life. In instances of extreme concentrations as in the case of radioiodine I^{131} administered to humans in the form of KI or NaI, greater accuracy can be obtained. It will be noted that the formula I for the dose, D_β , contains the half life of the element. If the amount of

iodine in the gland decreases both by decay and by excretion, the *effective half life* will be less than the physical. Such effects can be determined only by actual measurements. In this particular problem, counts are made at intervals with a Geiger counter in a fixed position over the thyroid gland. If there were no excretion of the material from the gland, these counts should decrease exactly in accordance with the physical decay curve for the iodine; that is, for I^{131} they should be at half their initial value

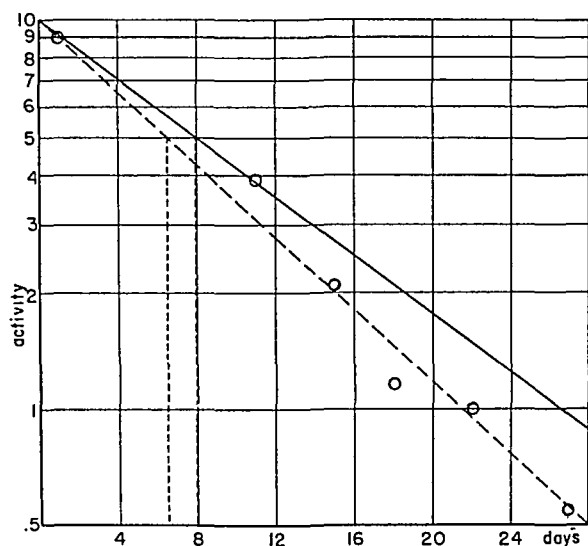


FIG. 2. Solid line: physical decay curve of I^{131} ; half life 8 days. Broken line: actual decay curve of I^{131} in a hyperthyroid patient; effective half life 6.5 days.

after 8 days, one-fourth at 16 days, etc. Actually, they decrease exponentially but more rapidly. Figure 2 shows the actual range of counts, in one patient treated with I^{131} for hyperthyroidism. The physical decay curve for the material is shown as a heavy line. It is obvious that the decrease was appreciably faster than this. The average "effective half life" in this case is 6.5 days (broken line). It is evident that the use of this number instead of 8 in equation I results in a decrease of 19 per cent in the administered dose, an amount which is probably clinically significant in therapeutic work. It would be now possible to calculate from formula I the dose delivered under normal conditions if the initial con-

centration C were known. This can be determined either by actual biopsy or "guessed" by estimate of the gland weight and measurements of the radioactive content of the gland by proper *in vivo* observations.

It is evident from Table I that the actual amounts of the *safe concentrations in tissue* do not vary very greatly; it must be realized that the intervals at which they can be repeated do. A reasonable interval between full tracer doses of any particular element would be four or five half lives, unless the material has been shown to be excreted fairly completely in a shorter period. If no significant excretion occurs, a tracer of Na^{24} could be repeated within about three days, while P^{32} should not be repeated in less than about 2 months, and Ca^{45} not before two years have elapsed.

It should be mentioned in this connection that the safe doses listed here are calculated on the assumption that the individual is receiving no radiation from any other source. Extensive radiographic or fluoroscopic procedures may result in an appreciable dose of radiation, and such possibilities must not be overlooked.

I-G. Tracer Isotopes—Examples. In order to illustrate the use of the material presented in this paper sample calculations will be given for some isotopes commonly used in tracer experiments and in therapy. These will be presented in order of the complexity of their spectra.

A) Radioactive Phosphorus— P^{32} —(Beta particles only)

If the isotope were evenly distributed throughout the body and no elimination took place the values of Table I would be directly applicable. Thus, if $2.4 \mu\text{c/kg}$ gives a dose of 0.1 e.r., an initial radiation dose of d e.r. per day will require a concentration $x \mu\text{c}$ per kg such that

$$2.4 \times 0.1 = x \times d$$

namely:

$$x = \frac{2.4 \times d}{0.1} = 24 \times d \mu\text{c/kg.}$$

If a total radiation dose D_β (e.r.) is to be given to a tissue, the concentration in that tissue should be such that

$$D_\beta = K_\beta C \text{ or } C = \frac{D_\beta}{885} \mu\text{c/gram.}$$

As already mentioned, the most exhaustive information on the distribution of this isotope in mice (16) shows that the highest radiation dose is given to bone, followed in order by spleen, liver, kidney, muscle and blood. In general, the limited information on adult humans obtained for the major part from autopsies of leukemic patients (3, 4, 5, 10, 20, 26), does not contradict the results in mice, provided that only non-infiltrated tissue obtained from patients given single doses of P^{32} be taken into consideration. Limited data on non-irradiated surgical material are also available (28). The most reliable D.A.R.'s on bone are of the order of unity though wide variations are noted not only among individuals but also among portions of the same bone (4, 28). The absolute value of the D.A.R.'s for human bone—as in the case of mice—seems to bear no detectable relation to the time elapsed between administration and assay; this points out to a slow “net” elimination of P^{32} from bone.

The highest D.A.R. reported on human marrow (10, 28) *devoid of leukemic infiltration* can also be taken of the order of unity for the first few days following P^{32} administration. Data on sternal aspiration (10), however, are decidedly lower, being much closer to that of blood. (Cf. Table VI loc. cit.). The latter in humans, receives “apparent” doses of the order of 20% of the theoretical whole body dose (13). It seems therefore that doses of the order of 2.4 $\mu\text{c/kg}$ of body weight can be safely administered, though they may produce wholly transitory but definite biological effects. Such reactions have been reported by Low-Beer and Treadwell for concentrations of 6–9 $\mu\text{c/kg}$ (29).

If P^{32} is administered intravenously in *insoluble form* (9) the deposition in the liver and spleen is likely to be very marked.

These authors report 80–89% in the liver (dog and mouse); if this were to obtain in humans the D.A.R. would be:

$$\text{D.A.R.} = \frac{\frac{\mu\text{c in liver}}{\text{liver weight}}}{\frac{\mu\text{c administered}}{\text{body weight}}} = \frac{0.89 \times 70}{1.7} = 36.7$$

1.7 kg being the weight of the average human liver (12). In this case the maximum permissible concentration would be

$$\frac{2.4}{36.7} = 0.066 \mu\text{c/kg of body weight}$$

or a total tracer dose of $0.066 \times 70 = 4.6 \mu\text{c}$ of P^{32} for a 70 kg man.

B) *Radioactive Strontium— Sr^{89} —(Beta particles only)*

Work on animals (18) indicates that this isotope is *highly concentrated in the bone*. Human material has been reported by Treadwell et al. (25) following intravenous injections. Their data point to a maximum D.A.R. in the epiphysis of bone of 13.2, and an unweighted average of 8.3 for bone, mostly in young subjects. A trend of D.A.R. change with time is not apparent. On the basis of this, the tolerance concentration would be

$$\frac{S_\beta}{8.3} = \frac{3}{8.3} = 0.4 \mu\text{c/kg of body weight.}$$

C) *Radioactive Calcium— Ca^{45} —(Beta particles only)*

The relative concentrations of this isotope in human tissue have not been reported to date. Work on mice shows that the D.A.R. for Ca in animal bone is approximately twice as that for Sr (18). Hence, if this ratio holds also for humans one should expect a D.A.R. of about $8.3 \times 2 = 16.6$.

It follows from Table I that the tolerance concentration would be

$$\frac{15.8}{16} = 1.0 \mu\text{c/kg of body weight.}$$

It should be noted that if calcium were

totally deposited in the human skeleton and the distribution were uniform the D.A.R. would be 10 (wt. of skeleton = 10% of body weight); nevertheless, the most active parts of the bone concentrate it more and hence the higher value adopted is not unreasonable.

It may be argued that on the basis of energy absorption in bone, the tolerance concentration just calculated for P^{32} , S^{89} and Ca^{45} could be increased by a factor of three because the energy absorbed per 0.1 r exposure in bone in the usual therapeutic x-ray range has been shown to be of the order of three times the energy absorbed per 0.1 e.r. of beta rays (21, 22). It is felt, however, that in view of the proximity of bone to marrow and of the long range of the beta rays involved, this may increase the energy absorbed in marrow to a value higher to that obtaining under body exposure of 0.1 r x-rays.

D) Radioactive Sodium— Na^{24} —(Beta and gamma radiation)

This isotope of sodium, administered orally or intravenously, is eliminated in very small amounts during times comparable to its half life. Since it is distributed rather uniformly throughout the body, computation of beta ray dosage can be made on the basis of D.A.R. = 1 (7, 8). The factor S_β of Table I can be applied directly in the case of small animals where the beta rays account for most of the radiation dose, the factor g in the gamma ray formula being very small. For larger animals and humans, however, the gamma ray contribution cannot be neglected. In this case dosage calculations become more involved.

As pointed out above the contribution of gamma rays to the daily tissue dose is $d_\gamma = C K_\gamma f_d g$ roentgens where

C = concentration in μc per gram of tissue

K_γ = roentgens at 1 cm per μcd

f_d = fraction of atoms destroyed in one day

g = geometrical factor which is a function of the size and shape of the tissue volume and the penetration of the radiation.

For purposes of calculation one may assume that the human trunk is a cylinder of radius $R = 20$ cm and height $2Z = 60$ cm, and that C is constant throughout. Under these conditions the highest dose is delivered at the midpoint of the axis and g can be expressed with sufficient approximation (Part II-B) as $g = 314 - 4140\mu$ where μ is the absorption coefficient of the gamma rays in tissue. For the gamma rays from sodium (see Table II and Fig. 5) the values of μ are 0.0296 and 0.0233 per cm respectively. An average $\mu = 0.025$ may be assumed for the present calculation and hence $g = 210.5$. Substituting for K_γ and f_d the values from Table II one obtains:

$d_\gamma = 0.40 \times 0.68 \times 210.5 C = 58.0 C$ r per day at the center of the trunk if C is given in μc per gram of tissue.

Similarly (Table I):

$d_\beta = 29 \times 0.68 \times C = 19.7 C$ e.r. per day if C is given in μc per gram of tissue.

Hence the total dose for the first day is $d_{\beta+\gamma} = 77.7 C$. The total dose $D_{\beta+\gamma}$ can be obtained from this figure. Since 68 per cent of the atoms disintegrate during the first day, 77.7 C is 68 per cent of the total dose. Hence

$$D_{\beta+\gamma} = \frac{100}{68} \times 77.7 = 114 C \text{ e.r.}$$

For the tolerance dose of 0.1 r/day,

$$S_{\beta+\gamma} = \frac{0.1}{77.7} = 0.0013 \mu\text{c per gram}$$

or 1.3 μc per kg of body weight.

E) Radioactive Sodium— Na^{22} —(Beta and gamma radiation)

The computation of tolerance dose follows closely that illustrated for Na^{24} except for the numerical values involved. Thus, $K_\gamma = 500$; $f_d = 6.3 \times 10^{-4}$; $g = (314 - 4140 \times 0.032) = 181$, since μ can be considered to be 0.023 for the purpose of this approximation.

Hence,

$d_\gamma = 500 \times 6.3 \times 10^{-4} \times 181 = 57 C$ at the center of the trunk and

$$d_\beta = 22,000 \times 6.3 \times 10^{-4} \times C = 14 C$$

$d_{\beta+\gamma} = 71C$ e.r. per day if C is in μc per gram of tissue.

$$D_{\beta+\gamma} = 11.3 \times 10^4 C \text{ e.r.}^*$$

$$S_{\beta+\gamma} = \frac{0.1}{71} = 0.0014 \mu\text{c per gram}$$

$$= 1.4 \mu\text{c per kg of tissue or body weight}$$

since C is considered constant throughout the body.

These two sodium isotopes offer a good illustration of the point made above regarding the repetition of tracer doses. Although the doses of the two isotopes which will give 0.1 e.r. the first day are essentially the same, the total dose from this amount of Na^{22} is much greater on account of its much longer half life and should not be repeated without careful knowledge of its excretion from the body. Conversely, the test dose of Na^{24} may be repeated much sooner.

F) *Radioactive Potassium— K^{42} —(Beta and gamma radiation)*

Under the same assumptions of distribution and elimination as in the case of Na^{24} , $K_{\gamma} = 0.0348$, $f_d = 0.739$ and $g = 198$.

$d_{\gamma} = 0.035 \times 0.74 \times 198 \times C = 5.2 C$ at the center of the trunk

$$d_{\beta} = 63 \times 0.74 \times C = 46.5 C$$

hence $d_{\beta+\gamma} = 51.7 \times C$ e.r. per day (C in μc per gram)

$$D_{\beta+\gamma} = 70C \text{ e.r.}$$

and finally

$$S_{\beta+\gamma} = \frac{0.1}{51.7} = 1.9 \mu\text{c per kg of body weight.}$$

G) *Radioactive Iodine— I^{130} —(Beta and gamma radiation)*

The distribution of radioiodine in the

* This dose ($D_{\beta+\gamma}$) would be delivered over a period of years if there were no excretion of the sodium. However, experimentally the material has a physiological half life of the order of one month or less, in normals and in individuals with congestive heart failure (24). In these cases the actual $D_{\beta+\gamma}$ is nearer to 3,000 C . For nephrotics excretion is very much slower, the biological half life may even approximate the physical, and the dose of radiation be correspondingly larger.

body is characterized by a *high and relatively stable deposition in normal thyroid tissue* and a low concentration in the rest of the body.

Assays in rabbits and rats (19) show that at various times after administration of iodide, most known radiosensitive tissues show average concentrations of the isotope close to that of blood. Unfortunately no information is available for the marrow. The concentration in thyroid tissue, however, is so markedly different from the rest of the body that the dosage problem assumes different aspects according to whether tracer studies or radical therapeutic procedures are contemplated. Full discussion of the latter is outside the scope of the present paper. In the case of tracer studies it is of interest to calculate merely the dose to the thyroid itself, since it is very unlikely that the radiosensitivity of any other tissue in the body is such as to overcome the very large thyroid D.A.R. From Table I the beta ray daily dose is readily calculated

$$d_{\beta} = 12.4 \times 0.73 \times C = 9.1 C.$$

For the calculation of d_{γ} , from Table II $K_{\gamma} = 0.237$; $f_d = 0.73$. The geometrical factor g is very different from the cases of sodium and potassium when the whole body dosage was considered. The usual gland (about 25 grams) can be considered made up of two separate spheres of radius equal to only 1.4 cm and for this calculation we may neglect the influence of the radiation from one lobe on the other. In this case $g = 4\pi(1 - e^{-\mu R}) \sim 4\pi R = 17.6$ since μR is very small. It follows that

$d_{\gamma} = 0.237 \times 0.73 \times 17.6 = 3.0 C$ at the center of the lobe. Hence

$d_{\beta+\gamma} = (3.0 + 9.1) C = 12.1 C$ e.r. per day, C being in μc per gram of thyroid weight.

$$D_{\beta+\gamma} = 16.6 C \text{ e.r.}$$

$$S_{\beta+\gamma} = \frac{0.1}{12.1}$$

$$= 0.0083 \mu\text{c per gram of thyroid weight.}$$

For a 25 gram thyroid this would mean $0.0083 \times 25 = 0.2 \mu\text{c}$ of I^{130} .

H) Radioactive Iodine— I^{131} —(Beta and gamma radiation)

Following the same pattern

$$d_{\beta} = 144 \times 0.083 \times C = 12C$$

and $d_{\gamma} = 0.735 \times 0.083 \times 17.6 = 1.1 C$ at the center of the lobe; hence

$d_{\beta+\gamma} = 13.1 C$ e.r. per day if C is in μc per gram of thyroid weight.

$D_{\beta+\gamma} = 158C$ e.r. (If there is no elimination.)

Therefore

$S_{\beta+\gamma} = 0.0076 \mu c$ per gram of thyroid and for a 25 gram thyroid this would mean 0.19 μc of I^{131} .

These doses, which deliver 0.1 r to the gland and only 1 per cent of this to the entire body, are obviously well below the accepted tolerance dose to the *whole* body. They correspond to oral or intravenous administration of 0.2 to 2 μc per patient (to account for excretions of 10 to 90%), and are sufficient for excretion studies as well as for assay of surgical biopsy material. They are, however, insufficient for radioautography with thin tissue sections, for extended studies of blood concentrations and for *in vivo* investigations of iodine retention by thyroid tissue by means of external counter measurements.

Studies on blood concentration and *in vivo* measurements would require doses of the order of 5 to 20 times those calculated (thyroid doses of 4 to 15 r in about three weeks, if I^{131} is used, taking into account elimination by the organ, and only 1/10 of that amount in two days in the case of I^{130}). Autoradiographic material can be obtained only with minimal concentrations of the order of several μc per gram of thyroid tissue (15). It seems therefore that in benign conditions, doses permitting excretion and tissue assays, blood concentration and *in vivo* measurements can be expected to produce no untoward effects, since the radiation is limited for a relatively short time to a very small part of the body which is not particularly radiosensitive. However, in the case of radioautographs, when radiation

therapy or total thyroidectomy is not contemplated, every effort should be made to obtain them with the fastest film and low photographic density (15).

At this point it should be brought out that when tracer studies are to be carried out once or a few times on an individual, for diagnostic purposes, the physician may legitimately employ doses considerably in excess of those giving only the radiation permitted for continuous exposure. The diagnostic radiologist does not hesitate to give local exposures of several roentgens, and to repeat these at need. The justifiable dose in such cases must be determined by the clinician responsible for the patient.

The above examples illustrate the fact that no general statement can be made regarding the relative importance of the beta- and gamma ray contributions to dosage. In the first place, the relative amount of energy emitted in the form of beta and gamma rays varies from one isotope to another. Also the geometrical factor g , which is a function of both penetration of radiation and size of organ, is likely to vary tremendously with the problem, as in the cases of sodium and iodine. This matter is discussed further in Part II where a formula is given for an approximate determination of the ratio of gamma ray dose to beta ray dose.

PART II. FUNDAMENTAL FORMULAE

II-A. *Beta ray and positron emitters.* One of the present authors published, in 1942, a preliminary paper on the determination of tissue doses from beta ray emitters (13). In order to correct some typographical errors in two of the formulae, and for the convenience of the reader, the fundamental relation of equivalence between concentration of beta ray emitters in tissue and radiation dose will be reproduced here.

Consider a mass of tissue, of linear dimensions large as compared to the range of ordinary beta particles, in which a radioelement is concentrated uniformly and is not being eliminated. It is obvious that, except for regions close to the boundary of the

mass, the energy D_β absorbed per gram of tissue will be

$$D_\beta = n\bar{E}_\beta \times 10^6 \text{ ev} \quad \text{V}$$

where $n = C/\lambda$ is the number of radioactive atoms per unit mass and \bar{E}_β is the average beta ray energy per disintegration in Mev. Now $n = 3.7 \times 10^4 \times C/\lambda$ where C is the concentration in μc^* per gram (or mc/kg) and λ the decay constant of the element in sec^{-1} .

Strictly speaking, D_β cannot be expressed in the same terms as the energy absorbed per gram of tissue per roentgen of x-rays since the latter depends on the composition of the tissue and on the wave length of the radiation. However, if one chooses as the unit the energy E_r absorbed per gram of air when the latter is exposed to one roentgen of radiation, this ambiguity is formally circumvented and D_β can be expressed in equivalent roentgens (e.r.). (See introduction.) From the definition of the roentgen, it follows that

$$\begin{aligned} E_r &= N_a \times W = 1.62 \times 10^{12} \times 32.2 \\ &= 5.22 \times 10^{13} \text{ ev} \end{aligned} \quad \text{VI}$$

where $N_a = 1.62 \times 10^{12}$, the number of ions formed in a gram of air per roentgen and $W = 32.2$ ev, the energy required to produce one pair of ions in air. It follows from V and VI that D_β can be expressed in equivalent roentgens by simple division, namely

$$D_\beta = \frac{3.7 \times 10^{10} C \bar{E}_\beta}{5.22 \times 10^{13} \times \lambda} \text{ e.r.} \quad \text{VII}$$

This expression can be modified into one more easily remembered if C is retained in μc per gram (or mc/kg) and \bar{E}_β in Mev, but T , the half life of the isotope, is expressed in days.

Since

$$T = \frac{0.693}{\lambda \times 8.64 \times 10^4} \text{ days,}$$

* By microcurie of any radioactive element is understood that quantity that disintegrates at the rate of 3.7×10^4 atoms per second.

equation VII becomes

$$D_\beta = 88 \bar{E}_\beta T C = K_\beta C \text{ e.r.} \quad \text{I}$$

where

$$K_\beta = 88 \bar{E}_\beta T \text{ e.r. per } \mu\text{cd/gram of tissue.} \quad \text{Ia}$$

From this formula others can be easily derived. Thus, for any interval of time t the dose d_β would be proportional to the fraction of atoms disintegrated during that time, namely

$$d_\beta(t) = D_\beta (1 - e^{-0.693t/T}) \text{ e.r.} \quad \text{VIII}$$

For $T > 5$ days, equation VIII can be written with an approximation of better than 1 per cent as

$$d_\beta = 61 \bar{E}_\beta C \text{ e.r. per day.} \quad \text{IX}$$

Similarly for $T > 5$ hours

$$d_\beta = 2.54 \bar{E}_\beta C \text{ e.r. per hour.} \quad \text{X}$$

Equation VIII is particularly useful in computation of the concentration necessary to deliver the so-called *tolerance dose of 0.1 r per day*; then $t = 1$ in order to get the dose for the first 24 hours. Thus, if S_β is defined as the concentration necessary to deliver the tolerance dose, it follows that

$$0.1 = K_\beta S_\beta (1 - e^{-0.693/T}).$$

By defining

$$f_d = (1 - e^{-0.693/T})$$

it follows that

$$S_\beta = \frac{0.1}{K_\beta f_d} \quad \text{XI}$$

Values of K_β , f_d and S_β have been presented in Table I (Part I A).

The values of \bar{E}_β were calculated as outlined in a previous paper by two of the present authors (14).* It is to be realized that \bar{E}_β depends on the disintegration scheme of the isotope under consideration

* In the paper referred to (14) are given references for the disintegration schemes of a large number of isotopes. A supplementary list of references, for additional isotopes considered in Tables I and II, is appended to the main bibliography of the present paper.

and that the latter is often complex. Some are established with satisfactory accuracy and constitute the Group A of Table I; those which are not yet very well known comprise Group B. Of these Sr^{90} is of particular interest since it decays into Y^{90} which is also a radioactive element (17). The given values of \bar{E}_β in Group C of Table I include the total localized x-radiation following the decay by electron capture. The x-radiation of the elements in this group is so soft that the resulting ionization is limited to a few mm of tissue. \bar{E}_β in Group D consists of that part of the radiation released by electron capture, which is available as Auger electrons and soft L-radiation. These last two groups are discussed in some detail in Section II C.

II-B. *Gamma ray emitters.* The determination of the dosage due to gamma radiation, originating from a stable distribution of a radioelement in a tissue, is greatly facilitated by the calculation of the constant I_γ which expresses the exposure in roentgens at 1 cm distance from an unfiltered unit point source in air during unit time interval. I_γ can be determined by calculating the ionization produced in a cc of air by the point source under the conditions stated above.

Let

P_γ = the number of gamma rays of energy E_γ , emitted per disintegration

N_e = the number of electrons per 1.293 mg of air (3.89×10^{20})

σ_a = the scattering absorption coefficient per electron (Compton)

τ = the photoelectric absorption coefficient per electron

σ_p = the pair production coefficient per electron

m_0c^2 = rest energy of the electron.

On account of the Compton, photoelectric and pair production processes, a gamma ray of energy E_γ will convert, per electron of air, a fraction μ_j of its energy into kinetic energy of secondary electrons, namely:

$$E_j \mu_j = E_\gamma (\sigma_a + \tau) + (E_\gamma - 2m_0c^2) (\sigma_p)_j.$$

In free air, if a spherical shell of 1 cm radius and thickness dr cm. has at its center a point source of 1 mc* of an isotope emitting a gamma ray of energy E_γ in a fraction P_γ of its disintegrations, that shell will receive energy at the rate

$$dF_\gamma = 3.7 \times 10^7 P_\gamma N_e E_j \mu_j dr \text{ (ev/sec.)}$$

The rate of energy absorption δF_γ , per cubic centimeter (1.293 mg.) of air under standard conditions is:

$$\delta F_\gamma = \frac{3.7 \times 10^7}{4\pi} \times P_\gamma N_e E_j \mu_j \text{ (ev/cc/sec.)}$$

Absorption of this energy will result in ionization, the measure of which in e.s.u. of current, is given by

$$(i_\gamma)_j = \frac{\delta F_\gamma}{n_j \times W} = \frac{3.7 \times 10^7 N_e}{4\pi n_j W} P_\gamma E_j \mu_j \text{ XII}$$

where $n_j = 2.08 \times 10^9$ is the number of ion pairs per e.s.u. of current, $W = 32.2$ ev is the energy per ion pair formed in air. From the definition of the roentgen it follows that equation XII expresses numerically the exposure in roentgens per second at 1 cm distance from a point source of 1 mc emitting P_γ gamma rays of energy E_γ per disintegration. A more convenient formula results if the hour is chosen as the unit of time and E_γ is expressed in Mev. Formula XII then becomes

$$(i_\gamma)_j = 6.14 \times 10^{25} P_\gamma E_j \mu_j \text{ r/hr/mc at 1 cm distance in air. XIII}$$

A plot of $(i_\gamma)_j$, as a function of E_j (for $P_\gamma = 1$) is shown in Figure 3. If the isotope has a complex spectrum of gamma rays of different energies E_j , each type emitted with probability P_j , then XIII becomes $I_\gamma = \sum_j (i_\gamma)_j$, namely

$$I_\gamma = 6.14 \times 10^{25} \sum_j P_j E_j \mu_j \text{ r/hr/mc at 1 cm distance in air. XIV}$$

The knowledge of the constant I_γ permits the prompt measurement in milli-

* 1 mc = 3.7×10^7 disintegrations per second.

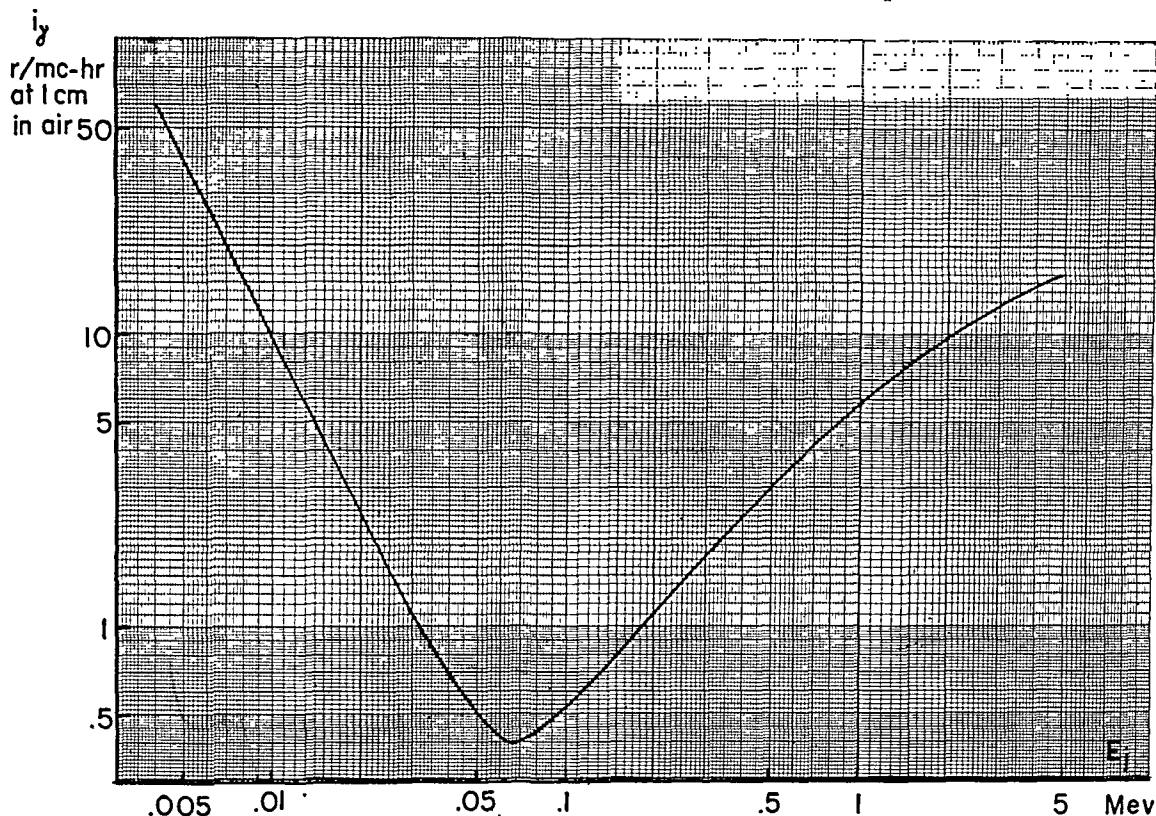


FIG. 3. i_γ in roentgens per mc-hour at 1 cm distance in air, as a function of the gamma-ray energy E_i in Mev.

curies of some gamma ray emitting isotopes, by the simple measurement of the dosage rate in roentgens. This constant is furthermore indispensable for the knowledge of therapeutic doses administered by discrete sources of known millicurie content.*

When the radioelement, by virtue of ingestion, injection, etc., is distributed throughout a tissue such as is represented by the volume V in Figure 4, with a concentration of c mc per gram, the dose rate per hour at any point O due to the quantity cdV of isotope present at a point Q , ρ cm distant from O , will be:

$$\delta d_\gamma = \frac{I_\gamma c e^{-\mu \rho}}{\rho^2} dV \text{ r/hour} \quad \text{XV}$$

where μ is the absorption coefficient of the radiation per cm of tissue.† More precisely

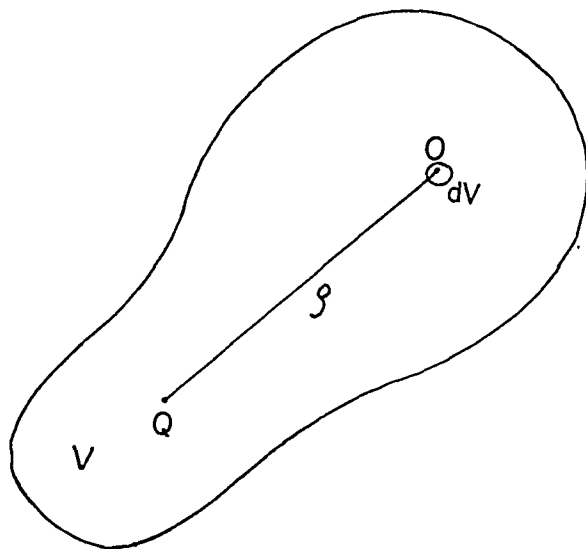


FIG. 4. Volume V with a concentration of C mc per gram.

* It should be kept in mind that a positron-emitter is always a gamma ray source, because of the annihilation radiation, even if there is no nuclear gamma radiation.

† The linear absorption coefficients μ , μ_j and the electronic absorption coefficient μ_e used in this paper do not include that por-

tion σ_s of the total absorption coefficient which relates to the scattered radiation of the Compton process. This procedure is entirely justified for a few cm of water (27) and introduces no appreciable error for at least 8 cm of Al, when the radiation is of hardness comparable to the gamma rays of radium (6).

for a complex spectrum, instead of $I_\gamma e^{-\mu\rho}$ one should have $\sum_j (i_\gamma)_j e^{-\mu_j \rho}$ where μ_j is the absorption coefficient for the gamma ray of energy E_j .

If the isotope is present in a uniform and biologically stable concentration of c mc per gram the *total dose rate at point O* due to the isotope in the whole tissue is

$$d_\gamma = I_\gamma c \int_V \frac{e^{-\mu\rho}}{\rho^2} dV \text{ r/hr.} \quad \text{XVI}$$

For the sake of brevity the integral

$$\int_V \frac{e^{-\mu\rho}}{\rho^2} dV$$

will be called the *geometrical factor g*. This coefficient must be calculated in each instance and it is exceedingly complex for non-uniform distributions.

For therapeutic dosage and protection

estimates it is more convenient to evaluate the total dose D_γ per microcurie destroyed (μcd)

$$D_\gamma = 1.44 t I_\gamma 10^{-3} C g = K_\gamma C g \text{ roentgens} \quad \text{III}$$

where

$$K_\gamma = \frac{1.44 t I_\gamma 10^{-3}}{\text{at 1 cm in air}} \text{ roentgens per } \mu\text{cd} \quad \text{IIIa}$$

in which t is the half life of the isotope in hours and C the concentration in μc per gram.

The dosage for the first day is obviously

$$d_\gamma (\text{day}) = K_\gamma C g f_d \text{ roentgen per day}$$

where

f_d is the fraction of atoms disintegrating per day. The dosages per hour are

$$d_\gamma (\text{hour}) = I_\gamma 10^{-3} C g \text{ for } t > 5 \text{ hr}$$

$$d_\gamma (\text{hour}) = K_\gamma C g f_h \text{ for } t < 5 \text{ hr}$$

where, as stated before, f_h is the fraction of atoms disintegrated per hour.

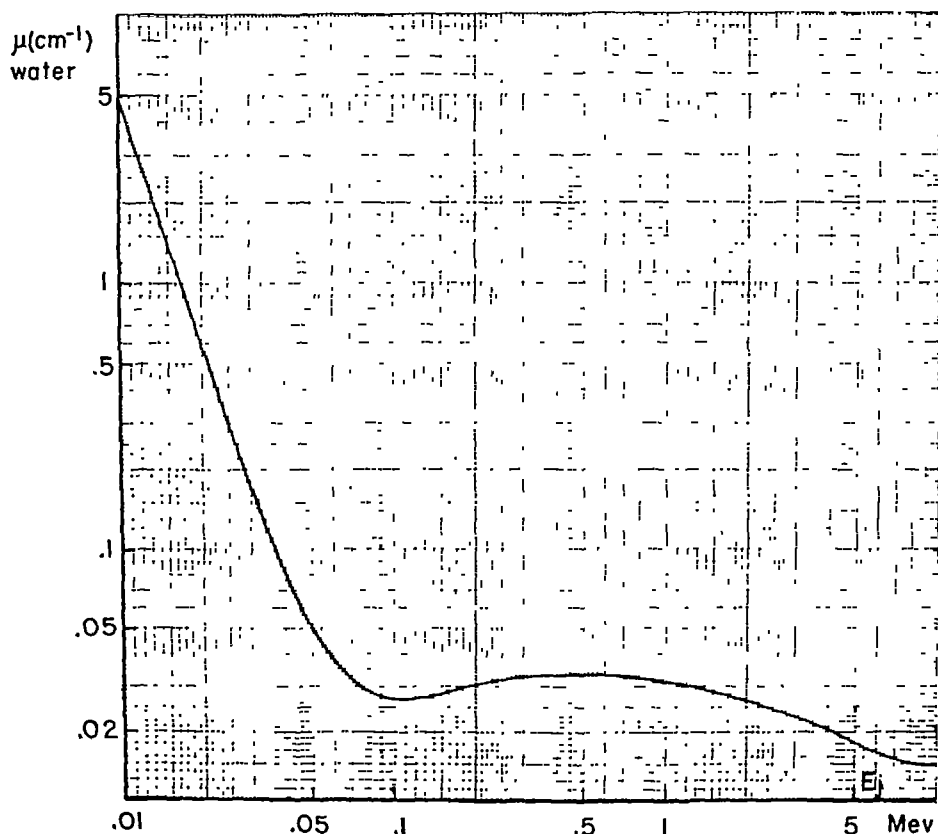


FIG. 5. Linear gamma-ray absorption coefficient μ , in water as a function of the gamma-ray energy E_γ . (μ , includes only the absorption caused by the liberation of photoelectrons, Compton electrons and electron pairs, but not that fraction due to Compton scattering.)

The values of $K_\gamma = 1.44 \text{ t } I_\gamma \times 10^{-3}$ have been presented in Table II. In this table the dose due to the annihilation radiation (two gamma rays of 0.511 Mev each per positron emitted) resulting from positron-electron recombination is included in the values given for K_γ . The values of the linear absorption coefficient μ_j in water (not including Compton scattering), as a function of the gamma ray energy E_j , are plotted in Figure 5.

For the sake of the illustrations presented in Part I-G the *geometrical factor* g^* will be evaluated for the center of a sphere of radius R and for the midpoint of the axis of a cylinder of radius R and height $2Z$.

In the first case for the *center of the sphere*,

$$g = \int_0^R \frac{4\pi \rho^2 d\rho}{\rho^2} e^{-\mu\rho} = \frac{4\pi}{\mu} (1 - e^{-\mu R}) \quad \text{XVII}$$

Since μ is of the order of 0.03 for most gamma rays (Fig. 5),

$$g = \frac{4\pi\mu R}{\mu} = 4\pi R$$

will be correct to within a few per cent for values of R as large as 10 cm.

For the cylinder, at the point O on its axis as indicated in Figure 6

$$g = 4\pi \int_0^Z \int_0^R \frac{r dr dz}{r^2 + z^2} e^{-\mu\sqrt{r^2 + z^2}}.$$

This expression is not directly integrable, but a fair approximation may be obtained by expanding the exponential term in a series and using only the first two terms:

$$e^{-\mu\sqrt{r^2 + z^2}} = 1 - \mu\sqrt{r^2 + z^2} + \mu^2 \frac{(r^2 + z^2)}{2!} - \dots$$

hence,

$$g = 2\pi \left\{ Z \log_e \left(1 + \frac{R^2}{Z^2} \right) + 2R \tan^{-1} \left(\frac{Z}{R} \right) - \mu [Z\sqrt{R^2 + Z^2} - Z^2 + R^2(\log_e [Z + \sqrt{R^2 + Z^2}] - \log_e R)] \right\}.$$

For

$$Z = 30 \text{ cm and } R = 20 \text{ cm } g = 314 - 4140\mu.$$

It should be realized that this approximation is justified only for relatively small values of $\mu\sqrt{R^2 + Z^2}$

In general a rough estimate of the ratio of D_γ to D_β at the *center of a spherical tissue* of radius R can be readily obtained by the formula

$$\frac{D_\gamma}{D_\beta} = \sum_j \frac{P_j E_j (1 - e^{-\mu_j R})}{\bar{E}_\beta} \quad \text{XVIII}$$

This expression follows from taking the

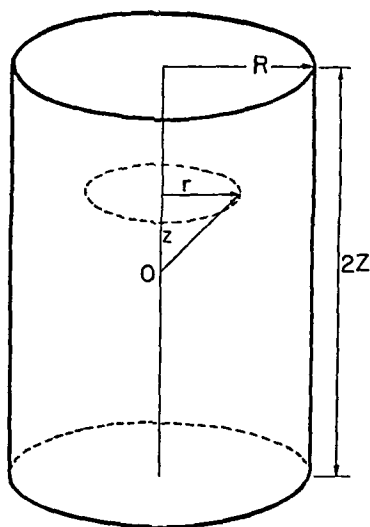


FIG. 6. Cylinder of radius R and height $2Z$.

ratio of D_γ , as expressed by the equations III, IIIa, XIV and XVII to D_β as in equation I and by taking $\mu_j(\text{cm}^{-1}) = n_e \mu_j^e$ where $n_e = 3.007 \times 10^{23}$, the number of electrons per gram of air. Equation XVIII, therefore, applies strictly only to a mass of tissue having unit density and the same atomic composition as air.

II-C. *Decay by electron capture.* The decay by electron capture presents a special case in dosimetry since it is followed by fluorescent radiation (K , L , etc.) and emission of Auger electrons. A rigorous determination of D_β and D_γ would require a precise knowledge of fluorescent yields ω_K , ω_L which is not always available (2). For

* Note that g can be calculated for only one point at a time and it is a function of its coordinates.

the purpose of this paper, however, some simplification of the problem is justified. The fluorescent quanta available have in general low energy and they are absorbed in small thicknesses of tissue. Ninety-five per cent of 9 kv radiation, for example, is absorbed within 5 mm of tissue; therefore fluorescent radiation of this voltage or lower can be treated in the same manner as beta radiation of comparable range.

Of the elements listed in Tables I and II it is seen that V^{48} , Mn^{52} , Cu^{61} , Cu^{64} and Zn^{63} decay partly by K -capture; the energy of their K radiation is lower than 9 KV. The energy thus available, moreover, is negligible compared to that from their beta or positron emission. For instance, in the case of Mn^{52} , having a relatively low value of $\bar{E}_\beta = 85$ kev, the ionization energy available by electron capture is, at most, the product of the energy of the hardest K line (5.4 kv) times the fraction (0.65) of atoms decaying by electron capture, namely 3.5 kv; this is only 4.2 per cent of the ionizing energy of the positrons. For the other isotopes mentioned above this ratio is still lower. For this reason, the contribution of the energy released following electron capture is totally disregarded for those five elements in both Tables I and II.

Four other elements, Mn^{54} , Fe^{55} , Co^{58} and Zn^{65} likewise emit soft fluorescent radiation which can be considered like beta rays. In this group of elements, however, the contribution of the extra-nuclear radiation to tissue dosage cannot be neglected because the average energy per disintegration of the nuclear corpuscular radiation is either zero (Mn^{54} , Fe^{55}) or very small. In Table I, Group C, therefore, \bar{E}_β and K_β take into account the fluorescent emission resulting from the disintegration of these elements by electron capture.

Obviously if the soft fluorescent radiation is treated like beta ray emission, its contribution to K_γ is neglected (Table II, Group B); however, its contribution to I_γ (corresponding to a fluorescent yield of $\omega_K \sim 0.3$) is stated in square brackets, only because similarly soft radiation can be

measured in roentgens (23) and might be useful in standardization problems.

The two isotopes Y^{86} and In^{111} decay wholly by electron capture followed by gamma rays. Their K -radiation energies are 14.2 and 23.1 kev respectively; hence they cannot properly be considered absorbed in the same manner as beta rays. To absorb 95 per cent of them would require about 2 and 8 cm of tissue respectively, which is far greater than the ordinary beta ray range. Since these isotopes emit no beta rays, the contribution of electron-capture process to radiation dose is likely to be important for small organs. Accordingly I_γ and K_γ have been calculated by taking into account (for the sake of a first approximation) the K fluorescent yield $\omega_K = 0.65$ and 0.75 respectively (2). These values, enclosed by square brackets, are presented in Table II, Group B in addition to the I_γ and K_γ resulting from their gamma ray spectra.

The remaining fraction of the energy ($1 - \omega_K$) would be available in L radiation and Auger electrons. Since both are of extremely small penetrating power they have been placed under \bar{E}_β and K_β (Table I, Group D), though no beta ray spectrum is present.

It is clear that the calculation of the total tissue dose, even for stable distributions, is in general a complex function of the type of radiation available and the dimensions of the tissue mass. As an illustration, curves are presented in Fig. 7 which show the variation of dose at the center of a sphere as a function of its radius. The curves are calculated for a uniform concentration of 1 $\mu\text{c/cc}$ of In^{111} and illustrate the contribution to the dose by the different types of radiation emitted by this radioelement.

II-D. *Metabolic elimination.* Elimination of a radioisotope from a given tissue obviously affects the dose delivered since a fraction of the atoms initially present will not disintegrate there. It will be convenient, in the general case in which elimination is irregular, to plot the actual concentration (as affected by both elimination and decay)

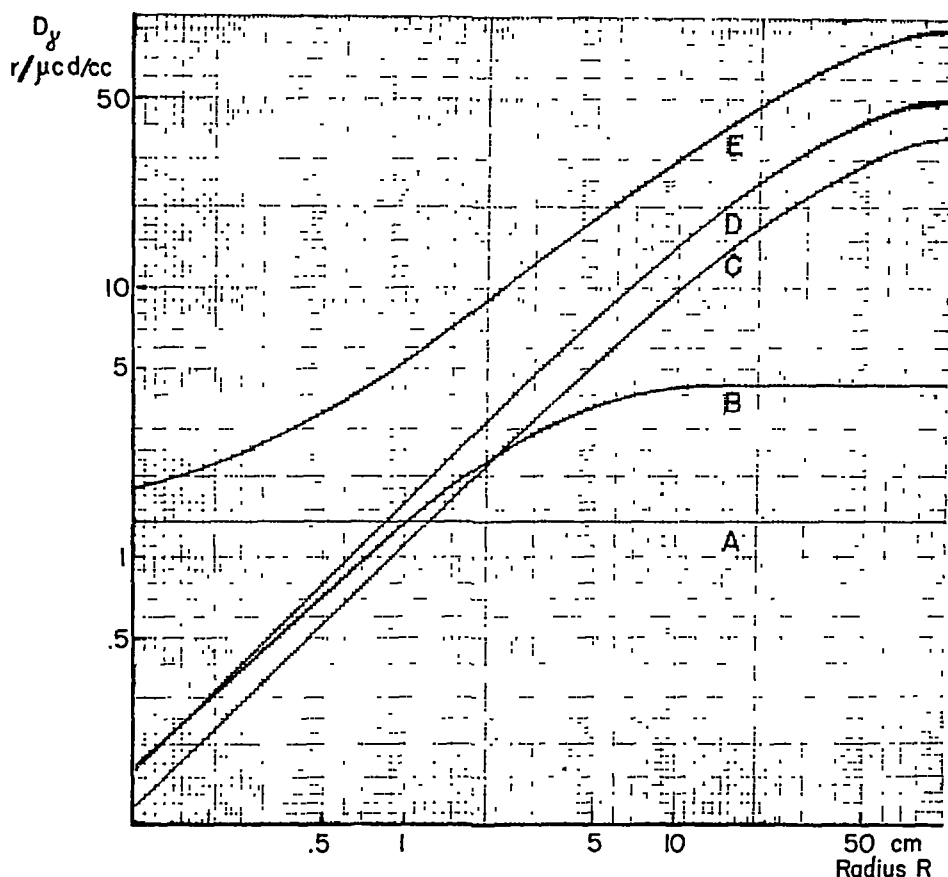


FIG. 7. Contribution of the gamma and x-radiation of In^{111} to the total tissue dose in roentgens at the center of a sphere as a function of the radius R of the sphere for a uniform concentration of one μc per cc completely disintegrated therein.

A: Auger electrons and L -radiation

B: K -radiation

C: 0.173 Mev gamma radiation

D: 0.247 Mev gamma radiation

E: Total tissue dose equals the sum of $A+B+C+D$

$C(t)e^{-\lambda t}$ as a function of time. (λ is the physical decay constant of the isotope.) The real beta ray dose Δ_β will be in general

$$\Delta_\beta = K_\beta \lambda \int_0^\infty C(t)e^{-\lambda t} dt \quad \text{XIX}$$

since $K_\beta \lambda$ represents the dose per unit time. K_β and $C(t)$ retain the values chosen for equation I.

Similarly for a gamma ray emitter

$$\Delta_\gamma = K_\gamma \lambda \int_0^\infty gC(t)e^{-\lambda t} dt$$

with the proviso that calculation be extended to the whole organism. For the simple case of uptake times small com-

pared to the half life of the isotope and in which $C(t)$ can be represented by the function $C_0 e^{-\lambda_b t}$ (λ_b being the constant rate of elimination)

$$\begin{aligned} \Delta_\beta &= C_0 K_\beta \lambda \int_0^\infty e^{-(\lambda_b + \lambda)t} dt = K_\beta C_0 \frac{\lambda}{\lambda + \lambda_b} \\ &= D_\beta \frac{T_b}{T + T_b} \end{aligned}$$

where the physical and biological half lives are

$$T = 0.693/\lambda \quad \text{and} \quad T_b = 0.693/\lambda_b.$$

Similarly

$$\Delta_\gamma = D_\gamma \frac{\lambda}{\lambda + \lambda_b} = D_\gamma \frac{T_b}{T + T_b}.$$

Hence in the case of *constant* rate of elimination in so far as total dose is concerned, the fundamental formulae I and III still apply, provided that by the half life is meant the *effective half life*

$$\frac{T \times T_b}{T + T_b}$$

of the isotope in the tissue as affected by both disintegration and elimination. This effective half life is the factor obtained directly from repeated measurements *in vivo* (Fig. 2).

II-E. *Miscellaneous formulae.* The weight of one millicurie of carrier free isotope can be readily calculated by noting that the weight of an atom of an element of atomic weight A is $(A/N) \times 10^3$ milligrams where $N = 6.02 \times 10^{23}$, Avogadro's number. Since one millicurie of an isotope contains $1.44 \times T \times 3.7 \times 10^7 \times 8.64 \times 10^4$ atoms (T in days) it follows that weight of one mc

$$1 \text{ mc} = \frac{1.44 \times 3.7 \times 10^7 \times 8.64 \times 10^4 \times 10^3}{6.02 \times 10^{23}} \times A \times T$$

$$= 7.65 \times 10^{-9} \times T \times A \text{ milligram.} \quad \text{XX}$$

Values derived from this formula for the various isotopes are presented in Table I, column 10.

It seems of interest to close this paper with an illustration of the weights of radioelements necessary to produce marked radiation effects. This can be done by the following considerations. In order to deliver one e.r. to a tissue by means of a beta ray emitting isotope a concentration C is required such that

$$C = \frac{1}{88 \bar{E}_\beta T} \mu\text{c per gram of tissue.}$$

In terms of weight

$$C = \frac{7.66 \times 10^{-12} \times 10^{-3} \times A \times T}{88 \bar{E}_\beta T}$$

$$= 8.7 \times 10^{-17} \frac{A}{\bar{E}_\beta} \text{ gram per gram of tissue.}$$

As an example, for P^{32} , $A = 32$; $\bar{E}_\beta = 0.7$ Mev; hence for a lethal whole body dose of 1,000 r the concentration required is

$$C = \frac{8.7 \times 10^{-17} \times 32 \times 10^3}{0.7}$$

$$= 3.98 \times 10^{-12} \text{ gram per gram of body weight}$$

(a total of 0.28 μ gram for a 70 kg man). Since phosphorus constitutes only 1.14×10^{-2} of the weight of the human body (1) only one atom in 2.85×10^9 atoms of phosphorus need be replaced on the average to obtain such an effect, on the assumption that no elimination takes place.

SUMMARY

When radioactive isotopes are employed either as tracers or in therapy, it is important to be able to determine the radiation dosage. This cannot, in general, be measured, but when the half life, radiation energy, and biological uptake and excretion are known, it can be calculated.

The paper is divided into two parts, based on clinical and physical aspects of the problem. In the physical part (Part II) are given mathematical developments of formulae for dosage rates and total doses for beta and gamma ray emitting isotopes, together with subsidiary formulae for safe concentration, weight per mc, etc. In the clinical part (Part I) these formulae are accepted, and doses considered for specific cases, for a number of isotopes of common interest. Particular consideration is given to the determination of safe tracer doses.

Since the basic information regarding radiation disintegration schemes and energies is scattered through many journals, it has been considered desirable to collect pertinent data. Two extensive tables are presented, for beta and gamma rays respectively, giving half life, radiation average energy, fraction disintegrating per day, and specific dosage data, including the safe tracer concentration, for some 38 isotope elements.

REFERENCES

1. BODANSKY, M. Introduction to Physiological Chemistry, 1934, 3rd edition, p. 4, J. Wiley and Sons, New York.
2. COMPTON, A. H., and ALLISON, S. K. X-Rays in Theory and Experiment. D. Van Nostrand Company, Inc., New York.
3. ERF, L. A. Clinical studies with the aid of radiophosphorus. II. The retention of radiophosphorus by tissue of patients dead of leukemia. *Am. J. M. Sc.*, 1942, 203, 529-535.
4. ERF, L. A. Retention of radiophosphorus in whole and aliquot portions of tissue of patient dead of leukemia. *Proc. Soc. Exper. Biol. & Med.*, 1941, 47, 287-289.
5. FORSSBERG, A. A study of the distribution of radioactive phosphorus in three cases of cancer. *Acta radiol.*, 1946, 27, 88-92.
6. GRAY, L. H. The rate of emission of gamma-ray energy by Radium B and Radium C and by Thorium B and Thorium C. *Proc. Roy. Soc. London Series A*, 1937, 159, 263-283.
7. GREENBERG, D. M., CAMPBELL, W. W., and MURAYAMA, M. The absorption, excretion and distribution of labeled sodium in rats maintained on normal and low sodium diets. *J. Biol. Chem.*, 1940, 136, 35-46.
8. HAHN, L. A., HEVESY, G. Ch., and REBBE, O. H. Do the potassium ions inside the muscle cells and blood corpuscles exchange with those present in the plasma? *Biochem. Jour.*, 1939, 33, 1549-1557. Table VI.
9. JONES, H. B., WROBELL, C. W., and LYONS, W. R. Method of distributing beta-radiation to reticulo-endothelial system and adjacent tissues. *J. Clinical Investigation*, 1944, 23, 783-788.
10. KENNEY, J. M. Radioactive phosphorus as a therapeutic agent in malignant neoplastic disease. *Cancer Research*, 1942, 2, 130-145.
11. KENNEY, J. M., MARINELLI, L. D., and WOODARD, H. Q. Tracer studies with radioactive phosphorus in malignant neoplastic disease. *Radiology*, 1941, 37, 683-687.
12. LISCO, H. The average man. Private communication.
13. MARINELLI, L. D. Dosage determinations with radioactive isotopes. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 210-216.
14. MARINELLI, L. D., BRINCKERHOFF, R. F., and HINE, G. J. Average energy of beta rays emitted by radioactive isotopes. *Rev. Modern Physics*, 1947, 19, 25-28.
15. MARINELLI, L. D., and HILL, R. F. (in preparation).
16. MARINELLI, L. D., and KENNEY, J. M. The absorption of radiophosphorus in irradiated and non-irradiated mice. *Radiology*, 1941, 37, 691-697.
17. MORGAN, K. Z. Tolerance concentration of radioactive substances. *J. Physical and Colloid Chemistry*, 1947, 51, 984-1003.
18. PECHER, C. Biologic investigations with radioactive calcium and strontium; preliminary report on use of radioactive strontium in treatment of metastatic bone cancer. *Univ. of Calif. Publications in Pharmacology*, 1942, 2, 117-149.
19. PERLMAN, I., CHAIKOFF, I. L., and MORTON, M. E. Radioactive iodine as indicator of metabolism of iodine; turnover of iodine in tissues of normal animal, with particular reference to thyroid. *J. Biol. Chem.*, 1941, 139, 433-447.
20. REINHARD, E. H., MOORE, C. V., BIERBAUM, O. S., and MOORE, S. Radioactive phosphorus as a therapeutic agent. A review of the literature and analysis of the results of treatment of 155 patients with various blood dyscrasias, lymphomas, and other malignant neoplastic diseases. *J. Lab. & Clin. Med.*, 1946, 31, 107-218.
21. SPIERS, F. W. Effective atomic number and energy absorption in tissues. *Brit. J. Radiol.*, 1946, 19, 52-63.
22. STENSTROM, K. W., and MARVIN, J. F. Ionization measurements with bone chambers and their application to radiation therapy. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1946, 56, 759-770.
23. TAYLOR, L. S., and STONEBURNER, C. F. The measurement of low voltage x-ray intensities. *J. Research Nat. Bur. Standards*, 1932, 9, 769-780.
24. THREEFOOT, S., GIBSON, T., and BURCH, G. Relationship of weight, venous pressure and radiosodium (Na^{22}) excretion in chronic congestive heart failure. *Proc. Soc. Exper. Biol. & Med.* (in press).
25. TREADWELL, A. DE G., LOW-BEER, B. V. A., FRIEDEL, H. L., and LAWRENCE, J. H. Metabolic studies on neoplasm of bone with aid of radioactive strontium. *Am. J. M. Sc.*, 1942, 204, 521-530.
26. WARREN, S. The distribution of doses of radioactive phosphorus in leukemic patients. *Cancer Research*, 1943, 3, 334-336.
27. WHITE, T. N., MARINELLI, L. D., and FAILLA, G. A measurement of gamma radiation in roentgens. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1940, 44, 889-903.
28. WOODARD, H. Q., and KENNEY, J. M. The relation of phosphatase activity in bone tumors to the deposition of radioactive phosphorus. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 227-242.
29. LOW-BEER, B. V. A., TREADWELL, A. DE G. Clinical studies with the aid of radio-phosphorus. V. Early effect of small amounts of radio-phosphorus on blood cell levels, uptake, and

excretion. *J. Lab. & Clin. Med.*, 1942, 27, 1294-1305.

- References for those isotopes which are not included in the paper of Marinelli, Brinckerhoff and Hine, Average energy of beta-rays emitted by radioactive isotopes. *Rev. Mod. Phys.* 1947, 19, 25-28.
- C¹⁴ LEVY, W. P., *Phys. Rev.* 1947, 72, 248.
- S³⁵ KAMEN, M. D., *Phys. Rev.* 1941, 60, 537.
- K⁴² SIEGBAHN, K., *Archiv. foer Mat. Astr. o. Fysik*, 1947, 34B, No. 4.
- Ca⁴⁵ Manhattan Project Announcement, *Science*, 1946, 103, 697.
- Sc⁴⁶ PEACOCK, CH. and WILKINSON, R. G., *Phys. Rev.* 1947, 72, 251.
- Mn⁵⁴ DEUTSCH, M. and ELLIOTT, L. G., *Phys. Rev.* 1944, 65, 211.
- Fe⁵⁵ BRADT, H., GUGELOT, P. C., HUBER, O., MEDICUS, H., PREISWERK, P., SCHERRER, P. and STEFFEN, R., *Helv. Phys. Acta*, 1946, 19, 222.
- Co⁶⁰ MILLER, L. C. and CURTISS, L. F., *J. Research Nat. Bur. Standards*, 1947, 38, 359.
- Zn⁶⁵ EVANS, R. D., *Nucleonics*, 1947, 1, No. 2, p. 39.
- As⁷⁶ SIEGBAHN, K., *Archiv. foer Mat. Astr. o. Fysik*, 1947, 34A, No. 7.
- Sr⁸⁹ RALL, W. and WILKINSON, R. G., *Phys. Rev.*, 1947, 71, 321.
- Sr⁹⁰ Manhattan Project Announcement, *Science*, 1946, 103, 697.
- Y⁸⁶ GAMERTSFELDER, G. R., *Phys. Rev.*, 1944, 66, 288.
- Y⁹⁰ Plutonium Project, *Rev. Mod. Phys.*, 1946, 18, 513.
- In¹¹¹ TENDAM, D. J. and BRADT, H. L., *Phys. Rev.*, 1947, 72, 1118.
- Sb¹²⁴ MEYERHOF, W. E. and SCHARFF-GOLDHABER, G., *Phys. Rev.*, 1947, 72, 273.
- I¹²⁸ SIEGBAHN, K. and HOLE, N., *Phys. Rev.*, 1946, 70, 133.
- Au¹⁹⁸ SIEGBAHN, K., *Proc. Roy. Soc.*, 1947, 189, 527.

DISCUSSION

DR. G. FAILLA, New York, N. Y. This is a very good and a very timely paper, especially as regards the doses which are permissible or which do not result in excessive irradiation of the body when the isotope is used for diagnostic purposes. As time goes on and isotopes and radiation of all kinds are used more and more, the question of protection becomes more important. As a matter of fact, at the present time there is quite a good deal of agitation to reduce the so-called tolerance dose or permissible daily dose of 1/10 r per day to a lower value, because a much larger proportion of the

population is going to be exposed to radiation in the future and, if we consider genetic effects, particularly, the situation becomes quite serious.

But I think when it comes to diagnostic procedure, the doctor can always justify the administration of a certain amount of radiation because it is essential to make a proper diagnosis. On the other hand, he would not know how much radiation the body is getting, or a particular organ of the body is getting, without the information provided by this paper. It is not complete in the sense that, as usual, the physical side of the problem is much easier to solve than the biological side. Dr. Quimby has shown us how one can calculate the amount of radiation that is delivered to a particular organ or to the whole body when a certain amount of radioactive isotope is ingested or introduced into the body, but the difficulty is in knowing exactly how much of that is going to be concentrated in a particular organ, how long it is going to stay there, and so on, and also the relative sensitivity of that organ with respect to the whole body. Those are things that have to be obtained by biological experiments and clinical observations, and the time will come, of course, when we will know a great deal more about that.

At any rate, irrespective of all the biological factors, one must know first of all the amount that is present in a tissue; that is, one must know how much radiation a certain amount of radioactive isotope will give in a tissue, and that information has been provided now and one can determine the safe limit of the amount of radioactive isotope that can be used and not exceed, say, 1/10 r per day, or whatever figure the radiologist chooses to adopt.

As I said before, for diagnostic purposes it is justifiable to exceed that dose. For experimental purposes, in order to get information from the use of radioactive isotopes on patients, it is another matter. One should be very careful there because of legal complications, and also because one could do some harm.

I think when the paper is published, it will be very useful to a great many people, both radiologists and others who are now using radioactive isotopes for diagnosis of treatment.

DR. KENNETH E. CORRIGAN, Detroit, Mich. As usual, Dr. Quimby has presented a very excellent paper, a very timely one, a very necessary one, and one that is very well done indeed.

The biggest difficulty with all of this work at the present time, which she barely mentioned, is the fact that those things which are known are badly scattered. Due to the necessity of secrecy for a while, and to other perfectly natural causes, the information which would normally be collected in a few readily available journals is spread through many journals and through many reports that are just now being declassified, so that to do research in this field of the type that we want here is extremely difficult.

I am glad that the matter of the tolerance

dose was mentioned. Our present concept of the tolerance dose is probably somewhat in error. Biological experimentation indicates that this may be true, and the tolerance dose for roentgen rays and gamma rays may very well be reduced. At the same time, there is evidence that the tolerance dose, as we now consider it, is not truly applicable to energetic particles, and the tolerance dose for beta rays may in the near future be something different from what we are now using.

This work is a solid foundation on which future studies of this sort may be built.



OPTICAL SYSTEMS FOR PHOTOFLUOROGRAPHY

PAPER II*

By GEORGE S. MONK, PH.D.

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CAMERAS that are to be used for recording the images of the fluorescent screen in photofluorography must have high speed and cover wide fields, but fortunately the demands that those requirements impose on the optical designer are encountered also in other fields. We owe to the requirements of one of the oldest sciences, astronomy, developments which are almost directly applicable to photofluorography; and since these developments came about in an attempt to correct the defects of ordinary astronomical telescopes, a summary of the simple theory of those defects probably will be of interest to radiologists.

An optical instrument designed to form images must gather a sufficient quantity of light and form a well-focused and sharp image of the object. The light-gathering power depends on the ratio of the focal length to the aperture; the smaller this ratio, the greater being the light-gathering power. When we say that a lens has a speed of $f/2.0$ we mean that the diameter of the usable aperture is one-half the focal length. The aperture is not always that of the lens itself, but may be a circular stop, real or virtual, which acts as the limit to the cone of rays taken in by the lens.

Light-gathering power is limited also by secondary factors, such as absorption of light by the glass, reflection from the surfaces of the lenses, and in the case of reflecting telescopes the efficiency of the metallic reflecting surface. The lens designer has techniques for reducing these secondary limiting factors but as he strives for greater and greater speed his primary

effort is to develop systems with larger apertures and smaller focal length. As the f /number is increased, however, the difficulty of bringing the rays to a sharp focus increases at a higher and faster growing rate because of difficulties which are known as optical aberrations. These aberrations can be classified into various types and fall into two groups: (1) primary aberrations, which are described below and which can be controlled to a considerable extent by the optical designer; and (2) complex, or higher order, aberrations, which largely set the limit, in f /number and field, in acceptable performance. These latter aberrations depend primarily on the general type of optical system used and, in effect, the history of optical progress is largely the invention of new types which reduce these complex aberrations to a minimum. The descriptions of the primary aberrations follow. The higher order aberrations are similar in general character but because they are considerably more complex in detail they are not here described.

Chromatic Aberration. Chromatic aberration is the failure of an uncorrected lens to bring light of different colors to the same focus. All transparent substances transmit light with a speed which depends on the color or, more precisely, the wavelength. As a consequence, rays of different colors are bent through different angles upon entering or leaving the glass, and do not arrive at the same focal point. If we select as that point the common meeting place of, say, the rays of a particular wavelength in the green, then with an uncorrected lens there will be a halo of other

* For Paper I of the Series, see AM. J. ROENTGENOL. & RAD. THERAPY, January, 1948, 59, 122-131

colors, noticeably blue and red, about each image point. The defect cannot be eliminated, but by the use of two or more lenses of different types of glass it can be reduced to a desired degree. Chromatic aberration is absent from reflectors coated metallically on the front surface since the angle of reflection for all colors is the same.

Geometrical Aberration. Even when the light is monochromatic no optical system will produce an image which is point for point and line for line a geometrically correct representation of the object because of the existence of faults that are known as "geometrical aberrations." These are five in number, namely:

- (1) Spherical aberration
- (2) Coma
- (3) Astigmatism
- (4) Curvature of field
- (5) Distortion

In the first three of these aberrations there is failure to bring rays from a given object point to a common image point

All except chromatic aberration are defects of reflectors as well as lenses.

For clarity in presentation the following paragraphs and illustrations deal with each aberration separately though actually, of course, all of them occur together in varying degrees whenever photographic images are formed. Most of the illustrations are from astronomy and the parallel light rays should be thought of as originating in a distant star lying sometimes on the axis of the lens and sometimes "off axis." If the optical system were perfect the image of the star would be a single sharply defined point.

Spherical Aberration. Spherical aberration is a fault caused by the spherical shape of lens or reflector surfaces. One cannot correct it for all object positions by changing the shape of the surfaces. A particular change of shape will correct the aberration only for a given object distance and position, and as a result of such a change the other four aberrations may even be affected adversely (Fig. 1).

TABLE I

Aberration	Variation with Image Size I	Variation with Aperture A
Confusion disk due to spherical aberration	Independent	A^3
Confusion disk due to coma	I	A^2
Length of astigmatic lines	I^2	A
Astigmatic focal separation	I^2	Independent
Confusion disk due to curvature of field if film is flat	I^2	A
Distortion	I^3	Independent
Confusion disk due to longitudinal chromatic aberration	Independent	A
Confusion disk due to lateral chromatic aberration	I	Independent

whereas in the last two the fault is a failure to produce in the image the same distribution of points in space as obtains in the object. In simple lens systems the geometric aberrations are apt to be severe, but even with skillful and complex optical design they can merely be reduced, never completely eliminated. The dependence of optical aberrations upon the aperture of the system and the angular size of image is shown in Table I. The meaning of the two astigmatic defects will be discussed later.

The parallel light rays from a distant star lying on the axis of the system do not meet at the same image point, those passing through the center of the lens being focused

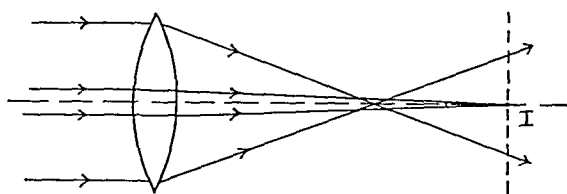


FIG. 1. Under-corrected spherical aberration.

at I , those passing through the outer zones of the lens being focused either nearer to or farther from the lens depending on whether the aberration is "under-corrected" or "over-corrected."

Coma. Contrasted with spherical aberration, coma is one of the defects found in images of stars *not* on the axis of the lens. In Figure 2 is illustrated a lens drawn so as

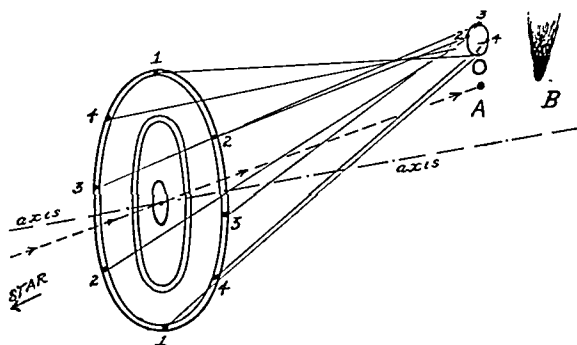


FIG. 2. Coma. *A* shows two comatic circles and point formed by light passing through three zones of the lens. *B* shows resulting comatic image from entire lens.

to show rays refracted through three zones, one at the edge, one somewhat nearer the middle, and one at the middle. For clarity the rays approaching the lens from the left are omitted. If coma and no other aberration is present, rays $1, 1$, at top and bottom of the outer zone will meet at a common point (1) in the image picture (*A*). Rays $3, 3$, will meet at point (3), and so on. Thus all the rays through this outermost zone of the lens will similarly meet in paired fashion to form a circle of light. Each such zone of the lens will form a similar circle of light, but the nearer to the middle of the lens, the smaller and brighter the circle will be. The light through the middle of the lens will form a bright point image, which will be nearest the axis, as shown in the figure, or, if the coma be opposite in effect, farthest away.

In (*B*), Figure 2 is represented the image of all the light of the star which passes through the lens, with a brush- or hair-like flare, called comatic flare, in the faintest part. This appearance gave rise to the name

Coma, from the Greek for hair. Coma appears in many simple or complex forms depending on the system used, and only a simple type is illustrated here.

Astigmatism. This, too, is an off-axis aberration. As shown in Figure 3, the image of a point, such as a star off the axis, is not a point. Even if coma were reduced or eliminated, astigmatism would still result in a pair of lines, one closer to the lens than the other, and perpendicular to each other. Of course, in most cases both astigmatism and coma are present, and may be difficult to separate although characteristics of both may be seen. It is customary to talk of two astigmatic aberrations: length of astigmatic lines, which is dependent on the aperture of the lens, and astigmatic focal separation, which is not.

Curvature of Field. For each off-axis point in the object there will be a pair of astigmatic lines lying on curved surfaces represented by the dotted curves in Figure 4*A*. Even if the astigmatism is made negligible, there is still the problem of getting a plane image. If it is important to get rid of this curvature, usually an attempt is made to get the astigmatic focal curves

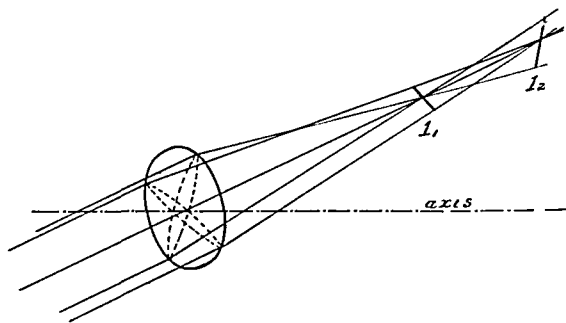


FIG. 3. Astigmatism causes a single point object to produce two line images.

to merge as nearly as possible over a large area of the image, as illustrated in Figure 4*B*.

Distortion. This is a failure to obtain uniform magnification over the entire field of view. Using a lens free from distortion the image of a grid of squares (Fig. 5*A*) will be like the object itself, with the same

magnification in all parts. When distortion is present, the image may appear barrel-shaped as in Figure 5B or pincushion-shaped as in Figure 5C.

Correction of Aberrations in Refractors. Since the aberrations are interdependent, the optical designer must balance corrections so as to obtain the best image for a

so-called "coated lenses." If the aperture is large, however, as in the case of a celestial telescope, it may be quite difficult to make clear disks of glass of optical quality that are of large enough diameter.

Astronomical Reflectors. These difficulties led telescope makers to turn to reflectors, especially since earlier astronomical observa-

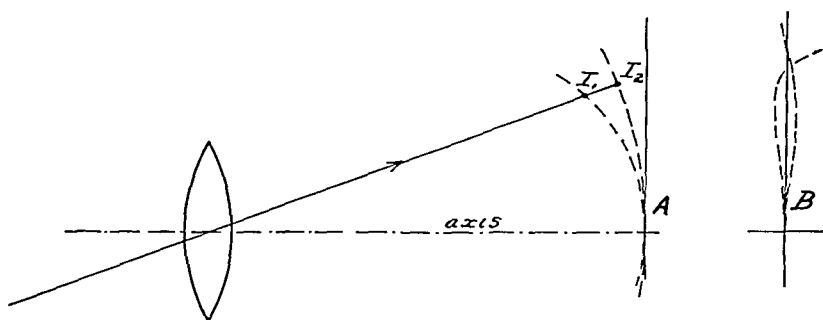


FIG. 4. Curvature of field. *A*, dotted lines show two astigmatic focal curves. *B*, some correction has been made.

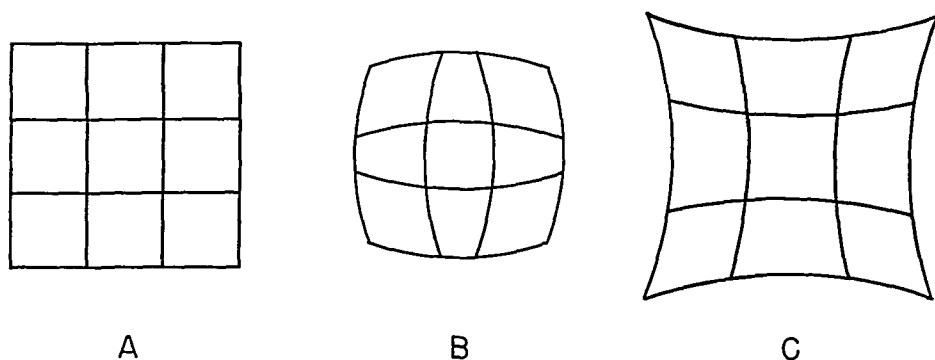


FIG. 5. *A*, no distortion; *B*, barrel-shaped distortion; *C*, pincushion distortion.

given set of conditions. He has at his disposal the curvatures of lens surfaces, their separations, the different types of optical glass, and the placing of stops at strategic positions. Spherical surfaces are used, since techniques of lens making have not yet progressed to the point where surfaces other than spherical may be made easily and in quantity. The design of a highly corrected lens, to cover a large field, requires that enough elements of selected types of glass be assembled, the number sometimes going as high as six or seven. The surface reflections and glass absorption may easily become serious, although there are now methods for reducing the former by using

tions were mainly by eye and limited to a small field on the axis of the instrument. With a parabolic reflector a star image on the axis may be obtained which is free from chromatic and spherical aberration, and if other parts of the sky are to be observed visually, the astronomer may easily turn to them.

Diffraction. Because of its wave nature, light gathered by a lens or mirror invariably is focused as a disk rather than a true point even though the source of the light be a point. In most astronomical work point images are greatly desired and camera designers exert much effort to reduce to a minimum the diameter of the image disk,

which is known as the circle of confusion. All else being equal, the smaller the f /number of the optical system, the smaller will be the circle of confusion, but, of course, there is no advantage in reducing disk diameter below the resolving power of the photographic material that is being used to record the stellar images.

The Schmidt Telescope. Photography, bringing with it the demand for still larger

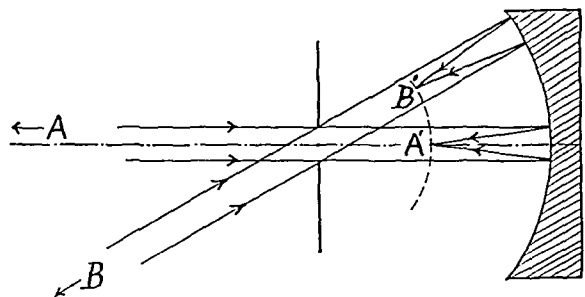


FIG. 6. Spherical mirror with small aperture at center of curvature. Such a system yields equally good images for all parts of the field but its speed is low.

apertures and high quality over larger field areas, stimulated the search for large aperture reflecting systems which would be free from the oblique aberrations, principally coma and astigmatism. In scientific research the celestial telescope is really a giant camera, and it is becoming customary to call it one. The problems of the camera lens designer are also those of the telescope maker. Used photographically, the telescope takes on the characteristics of a camera lens, requiring good image quality over a large field. At first, combinations of mirrors were used, the most notable contribution being that of Schwarzschild in 1905. He designed a reflecting system of two mirrors, free from coma and spherical aberration, having a flat field, and with the astigmatism balanced on two sides of the image plane. But while his research constitutes a high point in the theoretical study of aberrations, this did not solve the problem, for the speed of his design is no greater than $f/3$. Also, its overall length is too great for practical use.

The difficulty was finally overcome in a

novel manner, in 1931, by a telescope maker named Bernhard Schmidt, employed at the Hamburg Observatory in Bergedorf, Germany. The development of Schmidt's revolutionary idea will be first illustrated by reference to Figure 6.

An opaque diaphragm with a small aperture is placed at the center of curvature of a spherical mirror. Parallel rays from a distant point, A , on the axis will meet at a focus A' , midway between the diaphragm and the vertex of the mirror. If the aperture is small there will be negligible aberration since only a small part of the mirror is used for these rays.

Since the mirror is spherical, point B also is on the axis and the narrow bundle of rays originating at B is focused at B' . The same will be true for all other object positions and the resulting image surface is represented by a curved dotted line.

The drawback in the design represented in Figure 6 is the restricted aperture. But suppose we open it and put in a corrector plate P , Figure 7, with one surface so shaped that all of the rays through the enlarged opening are reflected to a common point. Then we have a corrected reflecting

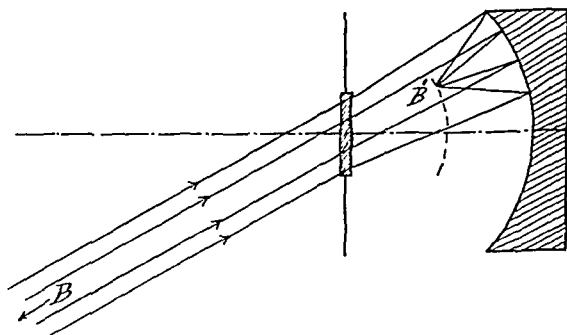


FIG. 7. Schmidt camera. An aspherical correcting plate at the center of curvature redirects the rays so that they are reflected to a good image point.

telescope of a sort never before conceived. Truly it is difficult to figure such a corrector plate, but Schmidt found that he could correct the coma and spherical aberration over a much larger area than by any other means.

The chromatic aberration of the correc-

tor plate is negligible and if it is made of quartz the telescope can be used to photograph wavelengths in the ultraviolet. This is a tremendous advantage over the refracting telescope, since transparent materials which will transmit the ultraviolet are limited in variety and unavailable in large sizes.

The field is spherical rather than flat but this drawback can usually be overcome in a surprising number of cases by bending or warping the film, and in some Schmidt cameras of relatively long focal length it can be overcome by adding a correcting lens placed very close to the film plane. In such a position the lens, usually plane on the side nearest the film, has very little effect on the focal length of the system, but flattens the image plane effectively. For large fields and at short focal lengths a corrector cannot be used with success.

At one stroke, Schmidt overcame two difficulties in celestial photography—restriction to small fields and limited relative apertures—and led the way in overcoming them in all other applications of optics.

Other Applications of the Schmidt Principle. After Schmidt had shown how his camera could be built the theory was quickly developed. This naturally opened the way to new possibilities in the design of similar systems, all using combinations of mirrors and thin refracting plates. This sort of combination of reflecting and refracting surfaces is known as a *catadioptric system*. In a variety of forms it has been adapted to astronomy, spectroscopy, television, and many other uses, now including photofluorography.

A drawback to the manufacture of the Schmidt camera is the great skill required to figure the aspherical corrector plate. Other catadioptric systems are easier to make. One of the earliest is a reflector invented over fifty years ago by Alphonse Mangin for projection of a beam of light. The reflector has the shape of a negative meniscus metallically coated for high reflection on the rear instead of the front

face, and by choosing the radii suitably the spherical aberration can be corrected. In a sense, Mangin's invention is a forerunner of catadioptric systems for image formation.

About ten years after Schmidt developed his camera, Maksutov in Russia patented a spherical reflector combined with a corrector plate which was a thin meniscus with spherical surfaces. He has since developed many variants of this design (Fig. 8),

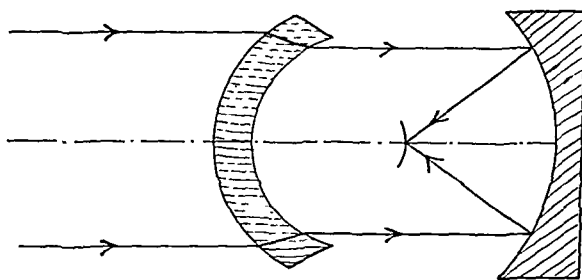


FIG. 8. Maksutov camera. A catadioptric system in which the correcting element is not a Schmidt plate but instead a meniscus with spherical surfaces.

which is highly successful for celestial telescopes. With a given thickness and with the proper choice of radius the chromatic aberration of the meniscus is zero and the residual spherical aberration quite small. By proper adjustment of the location of the surfaces the coma can be reduced.

There is an analogy between the catadioptric system and the corrected lens of the older type. When a lens is corrected by combining two lens elements, a negative and a positive, the spherical aberration of one is compensated by the opposite spherical aberration of the other; similarly, in a catadioptric system, the spherical aberrations of the meniscus and the reflector are opposite in sign. They are not quite equal, however, so that there remains a slight residual aberration, tolerable for focal ratios slower than $F/1.5$ or thereabouts, if the field of view is also rather small. Maksutov suggests reducing this residual aberration in some cases by modifying the sphericity of the surfaces to a very slight degree.

About the same time that Maksutov was developing his meniscus type instruments, others were developing modifications of the Schmidt type camera. These are too numerous to mention here, and the reader is referred to the bibliography for information regarding them. For ultra high speed cameras having large field, with moderate sized elements, a highly successful system is that used in the family of cameras developed recently by Henyey and Greenstein. Here the meniscus is made of two elements, the combination having external surfaces which are concentric. The glasses used have the same index of refraction and different dispersions. The centers of curvature of the external surfaces of the meniscus and of the reflector and the plateholder are all the same. This means that over the whole field the system can be considered to have the characteristics of an axial system, making possible correction of the off-axis aberrations to a high degree. This system is particularly valuable in photofluorography, where high speed and large angle are absolutely essential.

The attached bibliography is not expected to be a complete reference list to reading material on catadioptric systems. Many important developments are probably not available now because the requirements of national security still prevent their publication. The first group of papers should be easy reading for the layman. Those in the second group are mathematical and technical in the presentation.

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REFERENCES

I. Non-mathematical:

- SCHMIDT, B. Ein lichtestarkes komafreies Spiegel-system. *Mitteilungen Hamburger Sternwarte in Bergedorf*, 1932, 7, 15-17. Translated by N. U. Myall.
- DIMITROFF and BAKER. *Telescopes and Accessories*. Blakiston, Philadelphia, 1945.
- SMILEY, C. H. The Schmidt camera. *Popular Astronomy*, 1936, 44, 415.
- HENDRIX and CHRISTIE. Some applications of the

- Schmidt principle in optical design. *Scientific American*, 1939, 161, 118.
- MAKSUTOV, D. D. New catadioptric systems. *J. Optic. Soc. America*, 1944, 34, 270.
- ROSS, F. E. The optics of reflecting telescopes. *Publications of the Astronomical Society of the Pacific*, 1934, 46, 339.
- LEE, H. W. New lens systems. *Physical Society of London Reports on Progress in Physics*, 1940, 7, 130.

II. Mathematical or Technical:

- BAKER, J. G. The solid glass Schmidt camera. *Proc. Am. Phil. Soc.*, 1940, 82, 323. A family of flat field cameras, equivalent in performance to the Schmidt camera. *Proc. Am. Phil. Soc.*, 1940, 82, 339.
- HAWKINS and LINFOOT. An improved type of Schmidt camera. *Monthly Notices Royal Astronomical Society*, 1945, 105, 334.
- WYNNE. An extension of the lens-mirror system of Maksutov. *Nature*, 1946, 158, 584.
- ROSS, F. E. The 48-inch Schmidt telescope for the Astrophysical Observatory of the California Institute of Technology. *Astrophysical Journal*, 1940, 92, 400.
- WRIGHT, F. B. An aplanatic reflector with a flat field related to the Schmidt telescope. *Publications of the Astronomical Society of the Pacific*, 1935, 47, 300.
- CARATHEODORY, C. Elementare Theorie des Spiegelteleskops von B. Schmidt. *Hamburger Mathematische Einzelschriften*, 1940, 28.
- STROMGREN, BENGT. Das Schmidtsche Spiegelteleskop. *Vierteljahrsschrift der astronomische Gesellschaft*, 1935, 70, 65.
- SYNGE, J. L. Theory of the Schmidt telescope. *J. Optic. Soc. America*, 1943, 33, 129.
- SCHWARZSCHILD, K. Untersuchungen zur geometrischen Optik, I, II, III, *Astronomische Mitteilungen der Koniglichen Sternwarte zu Gottingen*, Parts 9, 10, 11, 1905.
- MANGIN and TSCHIKOLEW. *Arbeiten zur Scheinwerferfrage*. Translated to the German by A. Sonnefeld. *Ostwald's Klassiker der Exakten Wissenschaften* Nr. 219, 1927.
- VAISALA, Y. Ueber Spiegelteleskope mit grossem Gesichtsfeld. *Astronomische Nachrichten*, 1936, 259, 198.
- BENFORD, FRANK. Design method for a Schmidt camera with a finite source. *J. Optic. Soc. America*, 1944, 34, 595.
- MINKOWSKI, R. Schmidt systems as spectrograph cameras. *J. Optic. Soc. America*, 1944, 34, 89.
- SMILEY, C. H. Flare in Schmidt cameras. *J. Optic. Soc. America*, 1938, 28, 130.
- LUCY, F. A. Exact and approximate computation of Schmidt cameras. I. The classical arrangement. *J. Optic. Soc. America*, 1940, 30, 251. II.

- Some modified arrangements. *Ibid.*, 1941, 31, 358.
- HERZBERGER and HOADLEY. Calculation of aspherical correcting surfaces. *J. Optic. Soc. America*, 1946, 36, 334.
- GLANCY, A. ESTELLE. On the theory of computation of an aspherical surface. *J. Optic. Soc. America*, 1946, 36, 416.
- BENNETT, H. F. Concentric Maksutov-Schmidt reflecting systems. *J. Optic. Soc. America*, 1947, 37, 520.
- HENYEV, L. G., and GREENSTEIN, J. L. OSRD Report No. 4504. Wide Field Fast Cameras, 1945.
- LINFOOT, E. H. The Schmidt-Cassegrain systems and their application to astronomical photography. *Monthly Notices Royal Astronomical Society*, 1944, 104, No. 1. pp. 48-64.
- LINFOOT, E. H. Achromatized plate mirror systems. *Proc. Phys. Soc., London*, 1945, 57, 199.
- LINFOOT, E. H. On decentred aspheric plates. *Proc. Phys. Soc., London*, 1946, 58, 65.



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Publisher: CHARLES C THOMAS, 301-327 East Lawrence Avenue, Springfield, Illinois.

Issued Monthly. Subscription \$10.00 per year, \$11.00 in Canada and \$12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 301-327 East Lawrence Avenue, Springfield, Ill. Information of interest to all readers will be found on page iv.

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Forty-ninth Annual Meeting: Palmer House, Chicago Ill., Sept. 14-17, 1948.

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Thirtieth Annual Meeting: Stevens Hotel, Chicago, Ill., June, 20-22, 1948.



A CONGENITAL SYNDROME OF MECHANICAL ORIGIN

A NUMBER of cases of prenatal bowing and angulation of a single tubular bone or of a pair of tubular bones have been reported. Among the commonest of these deformities is congenital anterior curvature of one or both tibias or congenital tibial kyphosis. Chapple and Davidson have described a case of a newborn infant who presented congenital symmetrical lateral bowing of the femurs with bilateral dislocation of the hips, while the remainder of the skeleton apparently was normal, and the "position of comfort" assumed by the infant did not suggest faulty fetal position of the arms. Another observer has reported associated bendings in the femoral shafts of a newborn infant, who also exhibited bilateral tibial kyphosis and talipes equinus. It is of interest to note, however, that there were no concomitant deformities of the bones in the upper extremities in these cases reported which exhibited congenital curved deformities in the bones of the lower extremities.

Quite recently, Caffey¹ has reported prenatal bowing and thickening of tubular bones, with multiple cutaneous dimples in arms and legs. Included in Caffey's report are three cases of infants each of whom had congenital symmetrical bowings of the femoral and humeral shafts and similar, but sometimes unpaired, deformities of the shafts of the tibias, radii and ulnas. In each case the bowed diaphyseal segments were thickened, as well as bent. All curvatures extended through substantial longitudinal segments of the shafts in or near their middle thirds and large symmetrical cutaneous dimples overlay the salient

angles of the curves in several of the deformed bones.

Caffey comments that certain positive findings were common in all his cases. Multiple bowing deformities of the tubular bones of the extremities were present at birth, and the nature and magnitude of the skeletal lesions suggested that they had been developing a long time prior to birth. Each case was characterized by symmetrical lateral bowings of the femurs and symmetrical posterior bowings of the humeri. However, distal to the knees and the elbows the deformities of the bones were usually not symmetrical. At birth the cortical segments on the concave sides of the bony curves were thickened inwardly while the corresponding cortical segments on the convex sides of the same curves were unusually thin. Multiple cutaneous dimples were present in the deformed extremities in two of his cases.

The infants were born of healthy mothers and there was no evidence of inherited or familial skeletal or cutaneous disease. The infants themselves were healthy except for the deformities and the disabilities due to the deformities. The skeletal lesions were confined to the long tubular bones of the limbs; the bones of the hands, feet, head, thorax, pelvis and spine were not affected. Neither were there morbid changes demonstrated save in the skeleton and in the skin. There was no evidence of any of the intrinsic prenatal skeletal dysplasias which bring about deformities of the long bones of the fetus such as achondroplasia or dyschondroplasia. Neither was there evidence of osteogenesis imperfecta or pseudarthrosis. There was no clinical, roentgenographic, or serological evidence of prenatal or infantile rickets or syphilis.

¹ Caffey, John. Prenatal bowing and thickening of tubular bones, with multiple cutaneous dimples in arms and legs; a congenital syndrome of mechanical origin. *Am. J. Dis. Child.*, 1947, 74, 543-562.

While the pathogenesis of these prenatal deformities cannot be established by direct observation, Caffey brings forth considerable convincing evidence in support of the hypothesis that the bony lesions resulted solely from mechanical disturbances in utero, secondary to elocation of the fetal arms and legs. He speculates that these skeletal deformities may be explained satisfactorily by assuming that the fetal arms and legs were packed in attitudes which permitted the transmission of deforming uterine pressures from one impacted fetal part to another, and that the cutaneous dimplings, in like fashion, were brought about by pressure over the uterine wall on the fetal skin compressed on ectopic exposed bony points of the fetus.

Multiple angulations of the shafts due to prenatal fractures secondary to pseudarthrosis Caffey could easily exclude as the cause of the deformities of the bones in his cases as none of the cardinal signs of pseudarthrosis, such as focal degeneration of the bones, pathological fractures or false motion at the site of the diaphyseal angulation was evident in any of his cases.

From the analysis of his patients, Caffey concluded that the cutaneous dimples, the bowing of the long bones and the cortical thickening in the curved segments of the bones are all consonant with the hypothesis of simple mechanical molding of the displaced fetal arms and legs. He accepts Browne's postulate that ectopic dimples are stigmas of fetal compression. These dimples develop in the fetal skin in the sites of points of pressure between the maternal uterine wall and the superficial, sharp bony prominences of the fetal skeleton. The cutaneous depressions represent localized pressure atrophy of the subcutaneous soft tissues caught between the overlying uterine wall and the underlying bony prominences of the fetus.

Caffey states that the bowings of the tubular bones present at birth could have been caused by mechanical bending forces to which these bones were subjected long before birth, probably at first during an

early phase of fetal life, when these bones were largely cartilaginous and more easily bent. However, abnormal fetal position alone is insufficient to explain these skeletal deformities and Caffey postulates abnormal fetal posture in each case, one in which compressing forces were applied to the deformed bones at the sites of their concavities, and he calls attention to one feature of the bone lesions which was common to all three cases, namely the symmetrical lateral bowings of the femurs and the symmetrical dorsal bowings of the humeri. He states that the fetal extremities need only be folded into a cross leg and cross arm pattern, in which each foot presses on the internal aspect of its opposite thigh and each hand impinges on the flexor surface of its opposite upper arm, to bring about such deformities.

One of the striking features at birth of every one of the bowed bones is the thickening of the cortical segment on the concave wall of the curve and thinning of the opposite cortical segment on the convex wall of the curve. These cortical thickenings are limited to the curve itself, and all are directed inward; the caliber of the contiguous medullary cavity is correspondingly reduced. As a result of the analysis of the bone deformities in his cases, Caffey states that it is clear that this cortical hypertrophy represents accretion due to failure of absorption of the cortex from within and, on the other hand, does not represent subperiosteal accretion of the external cortical surface. This combination of cortical thickening on the concavity and cortical thinning on the convexity is, in Caffey's opinion, another example of structural adaptation of the affected bones to prenatal extraskeletal forces of compression which operated at the sites of the cortical thickenings.

The gradual postnatal regression of the bowings of the bones and of the cortical thickenings which Caffey noted in his cases further confirmed his opinion of the structural adaptation of the bone to disturbed fetal mechanics. He points out that the presence of bowed legs and crooked,

thickened bones with tibial and femoral spurring in his cases as late as two years after birth demonstrates that the late infantile clinical and roentgenographic changes residual to prenatal mechanical bowing closely resemble the deformities of healed early rickets and that this type of nonrachitic bowed legs might easily be mistaken for rachitic bowed legs, especially in the absence of cutaneous dimples or when the cutaneous dimples are present they are improperly interpreted, and he thinks it is quite probable that some of the cases that have been reported as instances of infantile tibial osteochondrosis were actually examples of prenatal bending of the bones in the legs, and he cautions against diagnosis of infantile tibial osteochondrosis unless necrosis of the medial tibial condyle is associated with bowing and medial spurring of tibiae and femurs.

From Caffey's careful analysis of his group of cases he concludes that the cause

and pathogenesis of the skeletal and cutaneous lesions have not been determined with certainty but there was much evidence in his cases which suggests that these deformities were caused by mechanical compression in utero operating on ectopic fetal extremities and that prenatal mechanical molding of the bones and pressure atrophy of the fetal skin are the probable pathogenetic mechanisms, and he emphasizes the similarity of this type of bowed legs caused by prenatal molding and the bowed legs due to rickets and to Blount's tibial osteochondrosis.

There is much in Caffey's discussion both from the clinical and the roentgenographic findings in his cases to warrant the deductions which he has made concerning prenatal bowing and thickening of the tubular bones with multiple cutaneous dimples in arms and legs and he thinks this is definitely a congenital syndrome of mechanical origin.





HARRY L. FARMER

1896-1947

DR. HARRY L. FARMER died December 6, 1947, at his home in Shaker Heights, Cleveland, Ohio. The cause of death was coronary thrombosis. He had been ill for a few months with congestive heart failure in the spring of 1947, but had resumed almost full time work again at the time of his death.

Dr. Farmer was born in Comanche, Texas, in 1896, and graduated from Baylor University Medical School in 1918. He went into service in the United States Navy Medical Corps where he served a year, during and after World War I. His internship was served at the Cincinnati General Hospital. Under Dr. George W. Holmes at

Massachusetts General Hospital, he obtained his radiological training during the years 1921-1923. He came to Cleveland to head the Radiological Department at City Hospital in 1923 and later joined the partnership with Dr. Walter C. Hill, Dr. George Thomas, and Dr. Merthyn A. Thomas, with whom he continued to practice. Dr. Farmer joined the American Roentgen Ray Society in 1928. He became a diplomate of the American Board of Radiology in 1934.

Dr. Farmer's many friends and his professional confrères will remember with inspiration his absolute integrity and his

warm friendliness. He exemplified perfectly the adage of an older generation "... there is always time for courtesy." His dependability and sense of duty kept him at work day after day, especially during the war years when fatigue and real physical anguish must have begged for relief. No pressure of work could force him to hasty or superficial judgment, and unselfish intellectual honesty pervaded his professional work throughout his entire life-time.

He will be missed by his associates and the entire radiological profession of Cleveland.

WALTER C. HILL



SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY

Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Palmer House, Chicago, Ill., Sept. 14-17, 1948.

AMERICAN RADIUM SOCIETY

Secretary, Dr. H. F. Hare, 605 Commonwealth Ave., Boston, Mass. Annual meeting: Stevens Hotel, Chicago, Ill., June 20-22, 1948.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1948, to be announced.

AMERICAN COLLEGE OF RADIOLOGY

Secretary, Mac F. Cahal, 20 N. Wacker Drive, Chicago 6. Annual meeting: Continental Hotel, Chicago, Ill., June 20, 1948.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION

Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: Chicago, Ill., June 21-25, 1948.

ALABAMA RADIOLOGICAL SOCIETY

Secretary, Dr. C. S. Stickley, 515 Bell Bldg., Montgomery, Ala. Next meeting time and place of Alabama State Medical Association.

ARKANSAS RADIOLOGICAL SOCIETY

Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

BROOKLYN ROENTGEN RAY SOCIETY

Secretary, Dr. A. H. Levy, 1354 Carroll St., Brooklyn 13, N. Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY

Secretary, Dr. Mario C. Gian, 610 Niagara St., Buffalo, N. Y. Meets second Monday evening each month, October to May inclusive.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY

Secretary, Dr. Dwight V. Needham, 608 E. Genesee St., Syracuse, N. Y. Three meetings a year. January, May, November.

CHICAGO ROENTGEN SOCIETY

Secretary, Dr. T. J. Wachowski, 310 Ellis Ave., Wheaton, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY

Secretary, Dr. Eugene L. Saenger, 735 Doctors Bldg., Cincinnati 2, Ohio. Meets last Monday of each month, September to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY

Secretary, Dr. George L. Sackett, 10515 Carnegie Ave. Cleveland 6, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

DALLAS-FORT WORTH ROENTGEN STUDY CLUB

Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

DENVER RADIOLOGICAL CLUB

Secretary, Dr. Mark S. Donovan, 306 Majestic Bldg., Denver 2, Colo. Meets third Friday of each month at Department of Radiology, Colorado School of Medicine.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY

Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA RADIOLOGICAL SOCIETY

Secretary, Dr. J. A. Beals, St. Luke's Hospital, Jacksonville, Fla. Meets twice yearly, in April preceding annual meeting of Florida Medical Society, and in November.

GEORGIA RADIOLOGICAL SOCIETY

Secretary, Dr. Robert Drane, DeRenne Apartments, Savannah, Ga. Meets in mid-winter and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY

Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

ILLINOIS RADIOLOGICAL SOCIETY

Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY

Secretary, Dr. J. A. Campbell, Indiana University Hospitals, Indianapolis 7. Meets second Sunday in May.

IOWA X-RAY CLUB

Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

KENTUCKY RADIOLOGICAL SOCIETY

Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY

Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOS ANGELES RADIOLOGICAL SOCIETY

Secretary, Dr. Moris Horwitz, 441 No. Camden Drive, Beverly Hills, Calif. Meets second Wednesday each month at Los Angeles County Medical Assn. Building.

LOUISIANA RADIOLOGICAL SOCIETY

Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

LOUISVILLE RADIOLOGICAL SOCIETY

Secretary, Dr. E. L. Pirkey, Louisville General Hospital, Louisville 2, Ky. Meets monthly on second Friday at Louisville General Hospital.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS

Secretary, Dr. R. D. McDuff, 220 Genesee Bank Bldg., Flint 3, Mich.

MILWAUKEE ROENTGEN RAY SOCIETY

Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY

Secretary, Dr. Chauncey N. Borman, 802 Medical Arts Bldg., Minneapolis 2, Minn. Two meetings yearly, one at time of Minnesota State Medical Association the other in the fall.

* Secretaries of societies not here listed are requested to send the necessary information to the Editor,

NEBRASKA RADIOLOGICAL SOCIETY

Secretary, Dr. Ralph C. Moore, Nebraska Methodist Hospital, Omaha 3, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

NEW HAMPSHIRE ROENTGEN RAY SOCIETY

Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

NEW YORK ROENTGEN SOCIETY

Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

NORTH CAROLINA RADIOLOGICAL SOCIETY

Secretary, Dr. J. E. Hemphill, 323 Professional Bldg., Charlotte 2, N. C. Meets in May and October.

NORTH DAKOTA RADIOLOGICAL SOCIETY

Secretary, Dr. C. O. Heilman, 807 Broadway, Fargo. Meetings held by announcement.

OHIO STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Carroll C. Dundon, 2065 Adelbert Road, Cleveland 6, Ohio. Next meeting at annual meeting of Ohio State Medical Association, Cincinnati, Ohio, March 31, 1948.

OKLAHOMA STATE RADIOLOGICAL SOCIETY

Secretary, Dr. P. E. Russo, 230 Osler Bldg., Oklahoma City, Okla. Three regular meetings annually.

OREGON RADIOLOGICAL SOCIETY

Secretary, Dr. William Y. Burton, 242 Medical Arts Bldg., Portland 5, Oregon. Meets monthly 2nd Wednesday, 8:00 P.M., Library of University of Oregon Medical School.

ORLEANS PARISH RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY

Secretary, Dr. S. J. Hawley, 1320 Madison St., Seattle 4, Wash. Meets annually in May.

PACIFIC ROENTGEN SOCIETY

Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY

Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport. Annual meeting, May 21-22, 1948, Erie, Pa., at Hotel Lawrence.

PHILADELPHIA ROENTGEN RAY SOCIETY

Secretary, Dr. C. L. Stewart, Jefferson Hospital. Meets, first Thursday of each month, October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY

Secretary, Dr. R. P. Meader, 4002 Jenkins Arcade Pittsburgh 22, Pa. Meets 6:30 P.M. at Webster Hall Hotel on second Wednesday each month, October to May inclusive.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY

Secretary, Dr. Harry A. Miller, 2452 Eutaw Place, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY

Secretary, Dr. Robert M. Lowman, Grace-New Haven Community Hospital, New Haven 11, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

RADIOLOGICAL SOCIETY OF NEW JERSEY

Secretary, Dr. Raphael Pomeranz, 31 Lincoln Park, Newark, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.

Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

Secretary, Dr. Maurice D. Frazer, 1037 Stuart Bldg., Lincoln, Nebr. Meets in Salt Lake City, Utah, 1948.

ST. LOUIS SOCIETY OF RADIOLOGISTS

Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September.

SAN DIEGO ROENTGEN SOCIETY

Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly, first Wednesday at dinner.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION

Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY

Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

SHREVEPORT RADIOLOGICAL CLUB

Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

SOUTH CAROLINA X-RAY SOCIETY

Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY

Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY

Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING

Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE

Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May inclusive. Room 203, Service Memorial Institute, 426 N. Charter St., Madison.

UTAH RADIOLOGICAL CONFERENCE

Secretary, Dr. Henry H. Lerner, School of Medicine, University of Utah, Salt Lake City 1. Meets 1st and 3rd Thursdays monthly from 7:30 to 10 P.M., Salt Lake County General Hospital, September to June.

UTAH STATE RADIOLOGICAL SOCIETY

Secretary, Dr. M. Lowry Allen, Judge Bldg., Salt Lake City 1, Utah. Meets third Wednesday in September, November, January, March and May.

VIRGINIA RADIOLOGICAL SOCIETY

Secretary, Dr. P. B. Parsons, Norfolk General Hospital, Norfolk, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Homer V. Hartzell, 310 Stimson Bldg., Seattle 1, Wash. Meets fourth Monday each month, October through May, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO

Secretary, Dr. Ivan J. Miller, 2000 Van Ness Ave. Meets monthly on third Thursday at 7:45 P.M., first six months of year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

CUBA**SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA**

President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

MEXICO**SOCIEDAD MEXICANA DE RADIOLOGIA Y FISIOTERAPIA**

General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

BRITISH EMPIRE**BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE ROENTGEN SOCIETY**

Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

FACULTY OF RADIOLOGISTS

Secretary, Dr. M. H. Jupe, 23 Welbeck St., London, W.1 England.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)

Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London.

CANADIAN ASSOCIATION OF RADIOLOGISTS

Honorary Secretary, Dr. E. M. Crawford, 2100 Marlowe Ave., Montreal 28, Que. Meetings January and June.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION

Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

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AUSTRALIAN AND NEW ZEALAND ASSOCIATION OF RADIOLOGISTS

Honorary Secretary, Dr. Alan R. Colwell, 135 Macquarie St., Sydney, N.S.W.

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New South Wales, Dr. E. W. Frecker, 135 Macquarie St., Sydney.

Victoria, Dr. T. L. Tyrer, 3 Lockerbie Court, East St. Kilda.

Queensland, Dr. J. Adam, 131 Wickham Terrace, Brisbane.

South Australia, Dr. B. C. Smeaton, 178 North Terrace, Adelaide.

Western Australia, Dr. A. M. Nelson, 179-B St. Georges Terrace, Perth.

New Zealand, Dr. E. G. Lynch, 12 Bolton St., Wellington.

SOUTH AMERICA**SOCIEDAD ARGENTINA DE RADIOLOGIA**

Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

SOCIEDADE BRASILEIRA DE RADIOTERAPIA

Secretary, Dr. Andreino Amaral, Av. Brigadeiro Luiz Antonio, 644, São Paulo, Brazil. Meets monthly on second Tuesday at 9 P.M. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

SOCIEDAD PERUANA DE RADIOLOGIA

Secretary, Dr. Julio Bedoya Paredes, Apartado, 2306 Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

CONTINENTAL EUROPE**SOCIÉTÉ BELGE DE RADIOLOGIE**

General Secretary, Dr. S. Masy, 111 Avenue des Alliés, Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.

CESKOSLOVENSKÁ SPOLEČNOST PRO RÖNTGENOLOGII A RADIOLOGII V PRAZE

Secretary, MUDr. Roman Blána, Praha XII, Korunní 160, Czechoslovakia.

POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. L. Zgliczynski, 59 Nowogrodzka St., Warsaw, Poland. Next meeting May 13 and 14, 1948.

GDANSK SECTION, POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. A. Smigielska, Akademia Lekarska, Gdansk. Meets monthly last Sunday at 10.30, X-Ray Dept., Akademia Gdansk.

WARSAW SECTION, POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. L. Zgliczynski, 59 Nowogrodzka St., Warsaw, Poland. Meets monthly.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE

Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD.

USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY

Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY

Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES

The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA

Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT (SOCIÉTÉ SUISSE DE RADIOLOGIE)

President, Dr. H. E. Walther, Gloriatstr. 14, Zürich, Switzerland. Annual meeting, on the Bürgenstock, near Lucerne, May 22 and 23, 1948.

SYMPOSIUM ON PULMONARY LESIONS

The Section on Radiology and the Section on Preventive and Industrial Medicine and Public Health of the American Medical Association will hold a joint scientific session in Chicago on June 25, 1948. This will be in the form of a symposium by clinicians and chemists who have been especially interested in the diagnosis, treatment and prevention of pulmonary lesions occurring in workers in certain industries.

Pulmonary affections of occupational origin have interested the radiologist for many years. Likewise, for many years, it has been held that the only substances apt to produce a disabling fibrosis were silica and asbestos. It was especially felt that practically all silicates were relatively inert. Recently, however, it has come to light that peculiar pulmonary pathology has occurred among bauxite workers, diatomaceous earth workers and among those exposed to beryllium or its acid radicals.

In order to bring the latest information regarding these from experienced radiologists, clinicians and pathologists, the Section on Preventive and Industrial Medicine and Public Health of the American Medical Association has invited the Section on Radiology to a joint session. The purpose of this notice is to call this to the attention of radiologists, for it portends an extraordinary symposium.

R. T. JOHNSTONE, M.D. Secretary, Section on Preventive and Industrial Medicine and Public Health

U. V. PORTMANN, M.D. Secretary, Section on Radiology

SIXTH INTERNATIONAL CONGRESS
OF RADIOLOGY

The radiologists of Great Britain through their National Radiological Committee have invited the Sixth International Congress to meet in London in the year 1950. The invitation has been accepted by the International Executive Committee and will take place either in July or September of 1950, the exact date to be determined later.

Dr. Ralston Paterson of Manchester, England will be the President of the Congress.

ARTHUR C. CHRISTIE, M.D.
President, Fifth International
Congress of Radiology

SCHWEIZERISCHE RÖNTGEN-
GESELLSCHAFT

The annual meeting of the Schweizerische Röntgen-Gesellschaft (Société Suisse de Radiologie) will be held on the Bürgenstock, near Lucerne, May 22-23, 1948. Hormonal diseases of bone will be the main subject of discussion. On application to the President of the Society, Dr. H. E. Walther, Gloriastr. 14, Zürich, Switzerland, a detailed program will be sent to members of American radiological societies who wish to attend the meeting.

CANCER SEMINAR

At Jacksonville, Florida, on November 12, 13 and 14, 1947, was held a "Cancer Seminar." The success of the novel undertaking may possibly prove a stimulus for similar endeavors in other sections of the country. The faculty was made up of physicians of such outstanding eminence in their special fields as to completely assure the highest excellence of presentation.

The success of the undertaking was manifest by the registration of 637 attending physicians from Florida, Georgia, and fifteen other states. (In fact, an estimated additional 150 physicians attended but failed to register, as there was no registration fee.) Attendance at each lecture was from 300 to 600.

The Seminar was organized by the Board of the Tumor Clinic of the Duval County Hospital, a local general hospital for indigent patients. The clinic has been operating for a year. Its Board is comprised of nine young physicians who are actively interested in the cancer problem. Most of them are recent veterans of the armed services.

Contributing largely to the success of the Seminar was the organized publicity which

preceded it, consisting of mailed invitations to all physicians of Florida and Georgia followed by mailing of the printed program, by invitations personally delivered before County Medical Society meetings, and by notices in the press and in the State Medical Journals. The Woman's Auxiliary of the local County Medical Society assisted materially in the clerical work.

The keynote of publicity was the assertion that the office of the private physician should be the best cancer clinic in the world.

The project was financed and otherwise assisted jointly by the Florida Division of the American Cancer Society and by the Florida State Board of Health.

It is the present plan of these organizations to promote a similar Seminar annually, at Jacksonville or at some other city in the southeastern section of the country.

The following are the subjects which were discussed by the visiting speakers:

November 12, 1947

Cancer of the Breast. Dr. Everett D. Sugarbaker.

Cancer of the Cervix Uteri. Dr. Emil Novak.
The Surgical Treatment of Cancer in Lymph Nodes. Dr. Everett D. Sugarbaker.

Cancer of the Stomach. Dr. Samuel F. Marshall.

Cancer of the Uterine Body. Dr. Emil Novak.
Meaning of Cancer Research. Dr. R. R. Spencer.

Surgical Management of Cancer Patients.
Dr. Everett D. Sugarbaker.

Cancer of the Ovary. Dr. Emil Novak.

November 13, 1947

Cancer of the Small and Large Bowel. Dr. Samuel F. Marshall.

Tumors of the Skin of the Face, Lip, Salivary Glands. Dr. James E. Scarborough.
Studies in Survival and Its Relation to the Cancer Problem. Dr. R. R. Spencer.

Tumors of the Lung. Dr. Herbert D. Adams.
Tumors of the Esophagus and Cardia of the Stomach. Dr. Herbert D. Adams.

Tumors of the Oral Cavity. Dr. James E. Scarborough.

Tumor Pathology. Dr. Everett L. Bishop.

Tumors of the Mediastinum. Dr. Herbert D. Adams.

November 14, 1947

Early Symptoms and Diagnosis of Tumors of the Genito-urinary Organs. Dr. Archie L. Dean.

Tumors of the Gallbladder, Bile Ducts and Pancreas. Dr. Samuel F. Marshall.

Diagnosis and Treatment of Pigmented Nevi and Melanomas. Dr. George T. Pack.

Treatment of Tumors of the Kidney, Ureter and Bladder. Dr. Archie L. Dean.

Tumors of the Nose and Sinuses, Nasopharynx, Pharynx and Larynx. Dr. James E. Scarborough.

Malignant Tumors of Bone. Dr. Everett L. Bishop.

Treatment of Tumors of the Prostate, Testicle and Penis. Dr. Archie L. Dean.

Management of Malignant Tumors of the Soft Tissues. Dr. George T. Pack.

J. A. BEALS, M.D.

St. Luke's Hospital Assn.
Jacksonville, Florida

LOUISVILLE RADIOLOGICAL SOCIETY

At the December meeting of the Louisville Radiological Society, Dr. Joseph C. Bell was elected Chairman, and Dr. Evert L. Pirkey was re-elected Secretary of the Society.

Dr. Bell has also recently assumed his duties as President of the Jefferson County Medical Society.

AMERICAN BOARD OF RADIOLOGY

Heretofore the American Board of Radiology has demanded that all candidates admitted to examination should be graduates of an approved Class A medical school. The Board has recently ruled, however, that those who have graduated from foreign and sub-standard medical schools before 1947 may be admitted to the examination if and when they have complied with the other requirements of the Board. No candidate who graduates from a sub-standard school (foreign or domestic) after 1947 will be admitted to the examination.

The Board has also ruled that a maximum credit of six months toward the required three years' training may be allowed for formal didactic courses in the basic sciences.

Many candidates who have applied for the entire field of Radiology or Roentgenology and who pass the examination in Diagnostic Roentgenology or possibly the Therapy part of the examination, ask for a limited certificate in the field in which they

have passed, expecting to re-apply shortly for the other field. This they are entitled to do but in order to discourage candidates taking partial certificates the Board has ruled that two years must elapse after a candidate accepts a certificate in one field before he may apply for additional certification.

B. R. KIRKLIN, M.D.
Secretary-Treasurer
American Board of Radiology



BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

RADICAL SURGERY IN ADVANCED ABDOMINAL CANCER. By Alexander Brunschwig, M.D., Professor of Surgery, University of Chicago. Cloth. Price, \$7.50. Pp. 324, with 118 illustrations. Chicago: University of Chicago Press, 1947.

Cancer of the gastrointestinal tract comprises more than half of all cancer. In the light of present knowledge the only hope of cure or palliation of these lesions lies in the activities of surgery. An infinite number of studies have been reported concerning the techniques of operation with their results in all phases of the disease. These observations show that the important deterrent to cure by operation lies in late diagnosis. The lesion itself is largely responsible since it frequently gives rise to symptoms severe enough to bring the patient to the physician too late for hope of cure.

Surgical techniques offer a better mortality rate than does the symptomatology of the disease. The cure rate from surgical treatment is not brilliant but it is good if the lesion is treated during the time when it is localized or has only metastasized to adjacent lymph nodes.

However, one encounters many patients with far advanced lesions often involving several organs, in addition to the original tumor. Consequently, the surgeon is frequently faced with the difficult and not infrequently insoluble problem of these treacherous lesions that have invaded adjacent organs and the abdominal wall that covers them.

Brunschwig reports in this book his attempts at surgical treatment of one hundred patients with far advanced cancer of the gastrointestinal tract in which other organs have been invaded and varied complications have been present. He gives case histories of these patients which are a summary of what one bold surgeon has accomplished in a field in which many surgeons have labored, perhaps in a less spectacular manner. These case presentations are complete and instructive. The details of preparation, operation and care are given in minutiae. The operations are perforce unusual and therefore instructive to all surgeons. The case method of

presentation makes the book personal and vivid. The content is clear and attractively presented. The accurate report of end results, both successful and otherwise, adds enormously to the information of the surgeon working in this field.

The development of our knowledge of the importance of preoperative preparation of the malnourished patient, the maintenance of nutrition during the postoperative period, the fact that shock following operation is due to blood loss and its prevention is accomplished by blood replacement has enabled surgeons to carry out operations of a magnitude not possible in the past.

Brunschwig has used all of this information in carrying out his radical surgical therapy so that he has attempted to extend the boundaries of the mechanistic attack on cancer and its spread by continuity.

No new principle is involved since all honest and skillful surgeons have attempted to accomplish the same end. The mortality rate of these operative attacks on otherwise hopeless lesions has been high and the cure and palliation rate have been low and not impressive. Nevertheless his spirit of indomitability in facing nearly hopeless situations is admirable and one that should be fostered. A defeatist frame of the surgical mind will deprive a few patients of cure and many of palliation. While the net results of such heroic surgery are not impressive and while one wonders whether such energy spent in other directions, such as earlier diagnosis, might not accomplish better results one can read this book with interest and profit.

The factors that enable Brunschwig to carry out operations of such magnitude are doubly important in the management of those patients in whom cure may be more frequently hoped for.

This phase of the treatment of the patients as recorded in this work makes it interesting reading for those of us who operate upon patients with cancer of the gastrointestinal tract. As an example of intelligent coordination and use of modern methods of preparing and maintaining

the patient's nutrition and well-being it is instructive. The book is a challenge to all of us to enlarge our operative indications and to improve our preparation and postoperative support. As a contribution to the treatment of cancer it is of minor importance; as a stimulant to the surgical pessimist in the operative treatment of cancer it is a strong counterirritant.

The binding and format are attractive, the paper of excellent quality and the line drawings and photographs are instructive and helpful. It is a unique presentation of what many consider a hopeless clinical problem. It can be read with interest by the finished surgeon but it contributes little to the solution of the problem of the management of patients with far advanced cancer.

FREDERICK A. COLLIER

BONE AND BONES: FUNDAMENTALS OF BONE BIOLOGY. By Joseph P. Weinmann, M.D., College of Dentistry, University of Illinois; Formerly at School of Dentistry, Loyola University, Chicago, and Harry Sicher, M.D., School of Dentistry, Loyola University, Chicago. Cloth. Price, \$10.00. Pp. 464, with 289 illustrations. St. Louis: C. V. Mosby Company, 1947.

This book is a compilation of accurate and detailed studies of the structure and growth of the various elements comprising normal bone and of the fundamental causes of the alterations in bone structure in growth disturbance, injury, displacement, endocrine imbalance, vitamin deficiency, circulatory interruption, inflammation, tumors and Paget's disease. The structure and growth of the facial bones and teeth are presented in detail.

The gross and microscopic aspects of both normal and abnormal structures are well illustrated and the chemical aspects of bone formation and destruction are well presented. The pathology of aseptic necrosis of the epiphyses of growing bones is adequately discussed but that of aseptic necrosis of the head of the femur following fractures of the neck and dislocation could have been more fully elaborated. No men-

tion is made of multiple aseptic bone infarcts produced by caisson disease and vascular lesions. For one who wishes to review the fundamentals of normal and pathological anatomy of bone, the book is highly recommended.

DALLAS B. PHEMISTER

RADIOLOGY FOR MEDICAL STUDENTS. By Fred Jenner Hodges, M.D., Professor and Chairman, Department of Roentgenology, University of Michigan; Isadore Lampe, M.D., Associate Professor, Department of Roentgenology, University of Michigan; and John Floyd Holt, M.D., Assistant Professor, Department of Roentgenology, University of Michigan. Cloth. Price, \$6.75. Pp. 424, with 103 illustrations. Chicago: Year Book Publishers, Inc., 1947.

As the name implies, this volume is intended as a reference manual or textbook to accompany a course in radiology. The authors have covered the subject well, including everything they believe the student should know about radiology before he embarks on his career as an intern and resident. Other textbooks on radiology are available, but most of them stress diagnosis rather than therapy. Here there is equal emphasis.

In the diagnostic section just enough about technique is given to put the students straight on the "whys" and "hows" of a particular examination. The illustrations and bibliography are carefully selected. The reproductions of roentgenograms as well as the diagrams are excellent. The authors and publishers are to be congratulated in this regard. The reviewer intends to use this text as a ready reference for students and thinks the book should have a wide use for this purpose. The radiologic profession has long been waiting for this type of volume which covers both the therapeutic and diagnostic fields in a concise, relatively brief, yet sufficient manner to give the medical student a proper appreciation of the radiologic approach.

PAUL C. SWENSON

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

ABDOMEN

NEUHAUSER, EDWARD B. D. Roentgen changes associated with pancreatic insufficiency in early life. *Radiology*, April, 1946, 46, 319-328.

This article is a summary of the author's experiences with 50 cases of pancreatic fibrosis. A brief review of the clinical and pathological findings in this disease is given. Farber is quoted as listing the following causes for a purely local process: atresia or stenosis of the pancreatic ducts; duct obstruction associated with certain forms of annular pancreas, and obstruction produced by calculi, neoplasms, and healed pancreatitis. In those instances where pancreatic fibrosis is but one manifestation of a widespread disturbance—and these constitute the majority of cases—there appears to be a failure of formation or a failure of liberation of pancreatic enzymes.

The roentgen examination is never diagnostic but is very suggestive in certain instances. When small intestinal obstruction is found in newborn infants and a clear-cut point of obstruction is not present, this condition must be thought of. In older patients with long standing disease the diagnosis is suggested by marked hypomotility and coarse rugal marking in the duodenum and jejunum.

The roentgen examination of the lungs frequently reveals changes quite characteristic. In the early stage the signs are those of varying degrees of bronchial plugging without superimposed infection. In the latter stages when infection is superimposed, multiple areas of peribronchial increase in density are seen and when confluent give the appearance of lobular pneumonia.

The diagnosis of pancreatic fibrosis is confirmed by the demonstration of marked reduction or absence of pancreatic enzymes.—*J. H. Harris.*

McENERY, E. T., and FOX, P. F. Foreign body in duodenum causing urinary disturbance. *J. Pediat.*, Aug., 1946, 29, 226-227.

This is a case report of a two year old child

who was admitted to the hospital with fever, nausea, vomiting and sore throat. His urine contained albumin and pus cells. The past history and physical examination were essentially negative. An intravenous pyelogram showed a bobby pin in the second and third portions of the duodenum. The upper half of the right ureter was enlarged several times the size of the left. At operation adhesions were found around the duodenum, involving the colon, liver and the upper pole of the right kidney. It was not known how long the foreign body had been present. This case presents an unusual cause for urinary disturbance.—*Rolfe M. Harvey.*

BRAUN, IMRE. Jejunal cancer—case report. *Am. J. Digest. Dis.*, July, 1946, 13, 234-237.

Primary tumor of the small intestine is an extremely infrequent lesion. Morrison discovered only 21 primary tumors in his 13,131 autopsies. According to the most recent survey by Mayo and Nettrour the incidence of cancer of the small intestine was 0.47 per cent of the total gastrointestinal cancers.

Braun describes the case of a fifty-three year old woman with vague abdominal complaints for about two years. During the months preceding the examination the patient was suffering from excruciating pain in the abdomen, radiating from the umbilicus to the left upper quadrant. This was accompanied by nausea and vomiting. The examination revealed a mass of fist size to the left of the umbilicus. The roentgeneological findings were a normal stomach and duodenum. After one hour the small intestinal loops were markedly dilated. After two hours a filling defect was found at the small bowel with a proximal distention of the small intestinal loops. At the six hour examination most of the contrast meal was found in the small intestine. At the twenty-four hour examination some retention was still present in the small bowel. At operation a constricting adenocarcinoma of the small intestine was found; however, no metastases were present.—*Franz J. Lust.*

MAIMON, SAMUEL N., and PALMER, WALTER L. Gastric carcinoma; incidence and diagnostic procedures. *Surg., Gynec. & Obst.*, Nov., 1946, 83, 572-574.

At the University of Chicago over a seventeen year period, gastric cancer was diagnosed in 576 patients. During the first few years of the institution's existence, the admissions were few; during the last years, they averaged 40 to 50 cases per year.

1. The incidence of gastric cancer will continue to rise as the average age of the population rises.

2. The incidence of gastric cancer rises sharply with advancing age, approximately three-fourths of the cases occurring in persons over fifty.

3. A trend toward earlier diagnosis is detectable.

4. The symptoms at the time the diagnosis was made were of less than three months' duration in one-fourth of the authors' cases, of less than six months' duration in 53.7 per cent.

5. Gastroscoy yielded the correct diagnosis in 84.6 per cent of the cases in which it was utilized.

6. Roentgen examination provided the correct diagnosis in 91.8 per cent of the cases so examined. It is worth while to note that the roentgenogram is not entirely reliable in determining the resectability of a lesion. In 400 cases, at the Mayo Clinic, about 50 per cent of those thought to be roentgenologically suitable for resection were found unsuitable at operation and, on the other hand, 39 others deemed unresectable on roentgen examination were removed at operation.

7. "Dyspeptic" symptoms appearing in patients of the "cancer age" warrant prompt roentgenologic and gastroscopic study.—*Mary Frances Vastine.*

BOYCE, FREDERICK F. Perforated gastric malignancy. *Surg., Gynec. & Obst.*, Dec., 1946, 83, 718-724.

A series of 36 cases is reported from Charity Hospital, New Orleans, and an additional case is reported of perforation of metastatic gastric cancer which represented an extension from primary adenocarcinoma of the pancreas.

Although only a small number of cases of perforated carcinoma of the stomach have been reported, the condition is by no means rare.

Diagnosis is not usually made before operation or necropsy; acute cases are likely to be regarded as perforated benign ulcer unless the malignancy has been recognized before the accident, and obscure cases are likely to be atypical and may present symptoms not related to the gastrointestinal tract. Primary gastrectomy is the ideal procedure but is usually impossible because of the advanced stage of the disease and the poor condition of the patient. The only solution of the problem, therefore, seems to be diagnosis and treatment of the gastric malignancy before the perforation occurs.—*Mary Frances Vastine.*

LONGMIRE, WILLIAM, JR. Total gastrectomy for carcinoma of the stomach. *Surg., Gynec. & Obst.*, Jan., 1947, 84, 21-30.

Total gastrectomy offers the most effective means of eradicating gastric carcinoma of the pyloric antrum and fundus. Since it is possible to perform total gastrectomy with a mortality rate of less than 10 per cent, and since the evidence at present indicates that gastrectomized patients maintain a satisfactory nutritional state, the more frequent use of the procedure is recommended. Certain lesions that would be considered inoperable if only subtotal gastric resection were employed may be adequately treated by total gastrectomy. Malignant lesions of a less extensive nature should be removed by total gastrectomy if adequate excision of the involved stomach and regional lymph nodes by subtotal resection is considered a doubtful undertaking.

Gastrectomized patients present problems associated with adequate intake and absorption of food, sometimes persisting for months after operation, which at present prevent the recommendation of the procedure as the operation of choice for all malignant tumors of the stomach which are amenable to surgical treatment.—*Mary Frances Vastine.*

HELWIG, ELSON B. The evolution of adenomas of the large intestine and their relation to carcinoma. *Surg., Gynec. & Obst.*, Jan., 1947, 84, 36-49.

Adenomas constitute the great majority of polyps occurring in the large intestine. In this paper the term adenoma is used to designate either a sessile or pedunculated benign tumor of glandular origin.

1. Adenomas of the large intestine are true

neoplasms and not a reaction consequent to a diffuse inflammatory process.

2. The incidence of adenomas of the large intestine increases with age. An appreciable increase in the incidence begins in the fourth decade and reaches a maximum (24 per cent) in the eighth decade.

3. Adenomas are more common in the white race than in the Negro.

4. Adenomas are slightly more frequent in men than in women in all sites of the large intestine.

5. In the series here reported on, 58 per cent of the patients with adenomas had single tumors. Single adenomas are more common in women (63 per cent) than in men (55 per cent).

6. Multiple adenomas are as common in the fourth decade as in the eighth decade of life in those patients who have adenomas.

7. Inflammation, hemorrhage and hemosiderin are commonly observed in the larger adenomas.

8. The incidence and distribution of adenomas of the large intestine have been carefully determined in 1,460 consecutive autopsies. Histologic evidence and cystologic evidence have been presented to the effect that adenomas of the large intestine undergo malignant transition.

9. Collateral evidence of the intimate relation of adenomas to carcinomas of the large intestine is cited. In this series both adenoma with malignant transition and manifest or unquestioned carcinoma are more common in the older age groups. Likewise, both adenoma with malignant transition and unquestioned carcinoma show similar sites of predilection in the large intestine.

10. Two carcinomas arising directly from the mucous membrane are described.

11. Such carcinomas of the large intestine arise directly from the mucous membrane but the majority develop in adenomas.—*Mary Frances Vastine.*

GAUSS, HARRY. Present trends in mucous colitis. *Am. J. Digest. Dis.*, July, 1946, 13, 213-220.

The present trend is to consider mucous colitis a neurosis of the colon, a form of psychosomatic disease in which the life conflict of a person has been mediated through the sympathetic nervous system to become localized in the colon. Mucous colitis is definitely as-

sociated with psychoneurotic states such as high tension states, anxiety states, submerged fear complexes, etc. The causes of a neurosis are manifold, complicated and prolonged in their genesis. It is seldom that a single factor produces a neurosis, although it may appear to do so. The gastrointestinal tract is the most likely organ which is used to express a neurosis; however, its good intentions are foredoomed to failure, as it was never intended to perform these functions. Its misguided efforts result in dysfunction of the viscera.

The common symptoms of mucous colitis are mucus in the stools, localized or diffuse abdominal pain, constipation, flatulence; also numerous other local and constitutional symptoms. The principal physical sign is the presence of spastic, palpable and tender descending colon of ropelike characteristics. The principal roentgen sign is the string sign which usually occurs in the descending colon. In considering treatment, it must be borne in mind that the patient has developed a vicious cycle in which psychic states produce an endless procession of reciprocal factors. This vicious cycle must be attacked and broken up at some vulnerable point.

Among the therapeutic procedures employed are psychotherapy, bed rest, relaxation, bland diets, sedatives, antispasmodics, physical therapy, demulcent gels. The prognosis is always guarded. The disease is never fatal, cures are sometimes obtained, recurrences are frequent; however, it is apt to be chronic and exist for years at a time.—*Franz J. Lust.*

GALAMBOS, A., and MITTELMANN-GALAMBOS, W. Diverticula of the colon versus gallstones. *Am. J. Digest. Dis.*, Jan., 1946, 13, 14-17.

A case of diverticulosis of the colon is presented with an unusual location of the diverticula. The barium-filled diverticula projected their shadow at the site of the gallbladder region. These shadows appeared in the shape, size, location, constellation, including even certain ring-shaped formation of the characteristic roentgen picture of gallstones. Subsequent films, on close inspection, revealed certain changes inconsistent with gallstones, but easily explainable by diverticular sacculations. The patient suffered, incidentally, from a superimposed cholelithiasis, as evidenced by the typical history and the failure to visualize the gall-

bladder and its contents by the routine method of cholecystography. The projected gallstone-like shadows on first impression might have been considered gallstones, responsible for the recurring severe biliary attacks. However, these shadows proved to be barium-filled diverticula, with their shadows projected at the gallbladder region, while the gallstones, being non-opaque and invisible to the roentgen rays, failed to be visualized.—*Franz J. Lust.*

GALAMBOS, A., and MITTELMANN-GALAMBOS, W. Redundancy of the colon. *Am. J. Digest. Dis.*, March, 1946, 13, 87-101.

Attention is called to the frequent occurrence of the abnormality known as redundancy of the colon which is significant from medical, surgical, pathological and roentgenological viewpoints. In a large percentage of cases redundancy exists without any symptoms or complaints. In such cases it presents an incidental finding. The diagnosis is established by roentgen examination. A three phase method has been suggested and described, and each individual part of this method has been appraised as to its respective value in the morphological or in the functional phase of the diagnosis.

Redundancy of the colon requires as its basic precondition an elongated mesentery. Failure of sufficient fixation during the development process permits the loosely attached colon or colonic segment free movement, similar to that prevailing with and typical of the small intestinal loops. On repeated examination with the opaque enema the authors found the redundant colon showing an entirely different shape and configuration. A twist, a kink, a reduplication, etc. along the descending colon may at some later, repeated examination show a new, grotesque configuration along the sigmoid, while the descending colon has been restored to normal shape. Or the picture of a horizontally tilted, S shaped, inverted cecum without an ascending but with a low transverse colon may at some other time change into a hypodescendant cecum with a short ascending but a low transverse colon, the three parallel branches of the inverted cecum being straightened into the latter configuration. There are endless variations in the changeable pattern along the redundant colon.

Failure of the free movability of the redundant loops, resulting on repeated exposures in a similarity of the morphological appearance, is suggestive of a pre-existing fixation due to ad-

hesions, congenital or acquired, developmental or inflammatory, more often over the right side of the abdomen. Large pendular movement of the colon develops basically upon the same foundation, namely, upon the pre-existence of an elongated mesentery. This, however, is a movement, an active process brought on by the function of the musculature of the colon. These slow, creeping, and wide-range movements result in pictures and configurations widely different from each other. As against this, the redundancy produces changes in the shape and configuration as a result of a passively attained incidental occurrence and is due to the free movability of the loosely attached loops. The large pendular movements most often occur in the transverse colon, with the hepatic and splenic flexures serving as fixation points of the segment undergoing this active movement. Redundancy affects mostly the sigmoid, with the longest mesentery and the least posterior attachment.

Volvulus, as the most important complication is redundancy, also requires an elongated mesentery for its development. Without redundancy, no volvulus; in redundancy, however, the occurrence of volvulus is extremely rare. Volvulus probably does not reach its full development in certain cases and may regress at any stage before finally peritonitis sets in, at a moment when a complete closure of the vessels which could result in gangrene of the affected area still can be averted. Recognition of such states remains very difficult. The most important problem in connection with redundancy is still the ascertainment of whether or not the case is well compensated, or is one with impending or actually existing failure of motor mechanism. The breakdown in muscular compensatory mechanism will result in partial retention of both the fecal matters and gases. Gas retention may result from failure of its transport or of its absorption, or it may be newly formed in the stagnating and decomposed fecal material in the redundant loops. Failure to medically correct the damage wrought by this chronic development may necessitate surgical intervention, especially in progressive cases. Establishment of a short circuit among the reduplicated and convoluted or twisted loops by exclusion and eventual resection of the chronically diseased extra loops should not represent an undue hazard in a well selected case. Proper recognition and management of the redundancy, especially by preven-

tion of any possible breakdown in the compensatory mechanism, may save suffering and complications.—*Franz J. Lust.*

CROMAR, C. D. L. Benign ulcer of the caecum. *Am. J. Digest. Dis.*, July, 1946, 13, 230-232.

Benign ulcer of the colon was first described by Cruveilhier in 1830 but it is still an uncommon disease for in 1939 Cameron, reviewing the literature of over a century, was able to find records of only 68 cases. About half of the ulcers have occurred in the cecum and ascending colon and have been situated with greatest frequency in the lateral wall of the colon diametrically opposite the opening of the ileocecal valve. According to Barlow the age incidence is highest between twenty-five and fifty years. Males are affected more commonly than females, especially when the lesion is situated in the right side of the colon. Coincident ulceration of the stomach and duodenum has been reported in 4 per cent of the cases. The etiology of the disease is obscure.

Cromar describes the case of a benign ulcer of the cecum where the patient was operated upon in the belief that he was suffering from appendicitis. A hemicolectomy was performed because the lesion was thought to be malignant. These ulcers have a tendency to cause perforation of the bowel. Just as in the reported case, the lesion may resemble a carcinoma. Conservative treatment is invariably fatal. The operative mortality is 40 per cent. Primary resection with re-establishment of the continuity of the bowel is the procedure of choice.—*Franz J. Lust.*

GENITOURINARY SYSTEM

KEARNS, W. M., HEFKE, H., and MORTON, S. A. Ditopax—a new excretory urographic medium; clinical report on 1280 injections. *J. Urol.*, Sept., 1946, 56, 392-398.

This is a report on the use of a new intravenous urographic medium, ditopax (bis-diethanolamine N-methyl-3,5 diidochelidomate); 1,280 injections were given to 1,232 patients.

A series of 10 cases was given alternate injections of ditopax and neo-iopax one week apart. On all these cases determinations were made of non-protein nitrogen, sugar, chlorides, blood pressure as well as electrocardiograms. No significant changes were noted in any of these determinations.

No reactions were noted in 75 per cent of 915 patients and "largely inconsequential" reac-

tions occurred in the remaining 25 per cent. Comparative urograms were made using ditopax, neo-iopax and diodrast. The films were interpreted separately by two roentgenologists and two urologists and graded according to diagnostic value. The results showed that in order of diagnostic value the dyes were neo-iopax, ditopax and diodrast.

Ditopax caused less arm pain than neo-iopax and less systemic reaction than diodrast.—*Rolfe M. Harvey.*

FLORENCE, T. J., HOWLAND, W. S., and WEENS, H. S. Intravenous urography in acute renal colic. *J. Urol.*, Sept., 1946, 56, 284-291.

Because the routine methods of study, such as urinalysis and survey roentgen films of the abdomen, which are usually employed in renal colic are often inconclusive, the authors studied an unselected group of 23 cases of renal colic by intravenous urography.

No preparation such as cleansing enemas or dehydration was employed. Fifteen cases with hematuria were studied. The survey roentgenogram revealed opacities along the course of the ureter in 11 of the 15 cases. In 4 of the 15 cases urography was necessary for confirmation of the diagnosis of ureteral calculus. Opacification of the kidney following intravenous administration of the dye as a result of ureteral obstruction, which the authors designate as a nephrogram, occurred in 10 cases. The authors explain this phenomenon as due to increased intrarenal pressure from the ureteral obstruction to the point where the glomerular filtration is suppressed. However, the tubular epithelium retains its function and excretes the dye into the tubular system causing a dense opacification of the kidney.

Nephrograms were obtained in 5 cases of calculus and 5 cases of non-calculus obstruction.

The authors conclude that intravenous urography is a worthwhile adjunct in the study of renal colic.—*Rolfe M. Harvey.*

LERNER, H. H., and GAZIN, A. I. Large pyelogenic cyst with crossed renal ectopia. *J. Urol.*, Aug., 1946, 56, 162-168.

This is a case report of a rare anomaly, a large pyelogenic cyst in association with crossed renal ectopia. The patient was a colored male, aged twenty-two, who complained of burning and epigastric fullness following meals. The duration was several years without relief from medication. Physical examination revealed a

large tense movable tumor extending from 2 inches above the umbilicus to 2 inches above the symphysis.

A survey film of the abdomen showed upward displacement of the gas-filled intestinal loops by the mass. Psoas muscle and kidney shadows were obscured. After injection of diodrast the dye appeared promptly in the left kidney which was rotated anteriorly and displaced laterally. The calices were blunted. The right kidney pelvis and ureter were not visible.

Gastrointestinal studies showed the stomach displaced upward and to the right. The descending colon and sigmoid were similarly displaced.

A catheter could not be introduced into the left kidney. A catheter introduced into the right ureter passed across the midline to the region of the previously visualized left kidney. Seven hundred cubic centimeters of urine were obtained following which the tumor mass which had been previously palpable disappeared.

A combined cystogram, intravenous urogram and ureteral catheterization proved the presence of crossed ectopia of the right kidney which was the site of a large pyelogenic cyst.—*Rolfe M. Harvey.*

RESNICK, B., and CLARK, J. H. Renal ectopia; demonstration of crossed unfused ectopia by fluoroscopy. *J. Urol.*, Aug., 1946, 56, 173-178.

The incidence of congenital ectopia of the kidney is usually reported as 1-1000. The authors noted an incidence of 1-91 in a series of 364 consecutive genitourinary studies. They feel that the incidence must be greater than is commonly suspected. They believe it is necessary to fluoroscope a patient after pyelography to detect the presence of a fusion. Absence of redundancy of the ureter is characteristic of congenital ectopia and distinguishes it from ptosis.

Ectopia renders a kidney more susceptible to pathological involvement. All the cases reported in this series were symptomatic. The diagnosis must be considered in all cases of abdominal or pelvic tumefaction.

The authors conclude their article with 5 case reports and illustrative films.—*Rolfe M. Harvey.*

HAYWARD, W. G. Hypernephroma in a polycystic kidney. *J. Urol.*, Aug., 1946, 56, 190-192.

This is a case report of a woman, aged seventy-two, who complained of a painless mass in the left upper abdomen of four months' duration. Frank hematuria occurred on the day of admission. The left pyelogram was reported as typical of renal tumor.

Surgical exposure of the left kidney revealed cysts of various sizes and colors. In addition, a tumor mass 13 cm. in diameter was present. This proved histopathologically to be a hypernephroma in a polycystic kidney.

The opposite kidney showed evidence of normal function and was negative by retrograde pyelography.—*Rolfe M. Harvey.*

WHITE, E. W., and BRAUNSTEIN, L. E. Cavernous hemangioma; renal vascular tumor requiring nephrectomy; unusual entity. *J. Urol.*, Aug., 1946, 56, 183-189.

Only 42 cases of renal angioma have been reported in the literature. Virchow believed that the liver is the commonest site for angioma and the kidney the next commonest. This belief is not substantiated by the opening sentence. The authors summarize the previous reports in the literature and submit the following classification: (A) benign: capillary hemangioma, plexiform hemangioma, and cavernous hemangioma; (B) malignant: hemangiosarcoma and hemangioblastoma.

The chief diagnostic symptom is uncontrollable hematuria. Pain is the variable symptom. The tumor may be detected by roentgenologic methods if it is of sufficient size to alter the renal architecture. In the differential diagnosis varicosities, small infarcts and early carcinoma must be considered.

The authors report a case in a forty-two year old woman who complained of pain and hematuria of short duration. Following a bilateral pyelogram the left side appeared normal but there was non-visualization of the middle calix of the right kidney. Neoplasm was considered to be the most likely diagnosis. A right nephrectomy was performed and histopathological examination revealed a cavernous hemangioma of the right renal pelvis.—*Rolfe M. Harvey.*

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Vol. 59

MARCH, 1948

No. 3

PNEUMOENCEPHALOGRAPHIC DIAGNOSIS IN THE PRESENILE DEMENTIAS*

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THE information provided by the pneumoencephalogram as to the presence or absence of cerebral atrophy is of great value in the differentiation of the presenile dementias from other conditions causing somewhat similar symptoms in middle life. Its value as a diagnostic means for differentiating among the various types of processes found in the presenile group is less definite and has been the subject of opposing reports. Specifically in the difficult differential diagnosis between Pick's disease and Alzheimer's disease, air studies have been considered on the one hand to be pathognomonic and on the other to be of little value. The former opinion is based largely on the work of Flügel⁵ who in 1932 reported on 24 cases of presenile dementia with encephalographic findings. The characteristic finding was symmetrical or asymmetrical ventricular enlargement without displacement especially involving the anterior horns. The type of distribution of the cortical air was considered to be a differential point between Pick's disease and Alzheimer's disease, the air in the former taking the shape of large confluent masses

over the frontal and temporal lobes and appearing in the latter as broad stripes over the entire convexity. The value of Flügel's report is vitiated by the fact that pathologic basis for the diagnoses was lacking in all except 6 cases in which brain puncture biopsies were performed. No reproductions of the encephalograms were presented in the paper. This work has, however, gained the sanction of authority and as recently as 1946 Jarvis⁷ states that "the air encephalogram is of great diagnostic value showing circumscribed cortical atrophy in Pick's disease in contrast to the diffuse type of atrophy in Alzheimer's."

The subject was critically reviewed by Romano and Miller¹² in 1940. They stated that with the exception of one case recorded by Bumke and Foerster³ they were unable to find any reproductions of encephalograms in published reports of Alzheimer's disease. Papers by Lemke,⁸ Nichols and Weigner,¹¹ Benedek and Lehoczky¹ and Fromenty⁶ all contained reproductions of encephalograms from cases of Pick's disease. Romano and Miller¹² concluded that the encephalographic pic-

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ture in Pick's disease was fairly uniform, being characterized by dilatation of the lateral ventricles, increase of intergyral air spaces more marked in the frontal and temporal areas, and confluent masses of air over the frontal and temporal lobes. On the other hand, an encephalogram made four years before death in the case of Malamud and Boyd¹⁰ showed only moderate and symmetrical dilatation of the lateral ven-

of 10 patients seen over a number of years at St. Elizabeth's Hospital, the opportunity arose to evaluate the role of the pneumo-encephalogram both in the delimitation of the presenile group from other cases and in the differential diagnosis of Pick's disease and Alzheimer's disease. In all cases the diagnosis of presenile dementia was made on the basis of a progressive organic dementing process having its onset in middle



FIG. 1. Case 1 showing marked and uniform dilatation of both lateral ventricles without distortion or displacement. Very little extracortical air is visible. Pathologically this was a case of Alzheimer's disease.

tricles while at autopsy there was circumscribed symmetrical atrophy of the temporal lobes.

The usefulness of air encephalography in the differential diagnosis of Pick's disease and Alzheimer's disease has also been criticized on pathologic grounds. Thus, both Bouton² and McMenemey⁹ point out that some cases of Pick's disease do not show gross lobar atrophy while local accentuation of atrophy may be quite striking in some cases of Alzheimer's disease. This latter finding has been emphasized by Rothschild and Kasanin¹³ in 2 of 5 autopsied cases. Referring to its use in the differentiation of the various members of the presenile group, Critchley⁴ calls the encephalogram a "treacherous short cut to diagnosis."

In the course of a clinicopathologic study in the presenile dementias based on a group

life without evidence of specific infectious, luetic, toxic or arteriosclerotic etiology. Nine of the 10 cases have died and autopsies have been performed on all but one of the cases.

CASE REPORTS

CASE 1. J. L. B., a male, white, aged fifty-eight, was admitted to St. Elizabeth's Hospital on May 6, 1939, because of progressive intellectual deterioration and personality change which had first been noticed in 1936 when he was fifty-five years old. After hospitalization his course was steadily retrogressive and after some years of a vegetative existence he died on May 1, 1941.

Air encephalography, performed on December 19, 1939, revealed marked uniform dilatation of the lateral ventricles with an almost complete absence of visible extracortical air (Fig. 1).

At autopsy there was great dilatation of the

ventricular system with great reduction of the subcortical white matter and thinning of the cortex. There was no focal lobar atrophy. The microscopic findings were compatible with Alzheimer's disease.

CASE II. G. A., a female, white, aged fifty-seven, was admitted to St. Elizabeth's Hospital on June 7, 1937, because of the gradual development of faulty memory, difficulty in reading, untidiness and paranoid delusions. The first symptoms were noted in 1927 at the age of forty-seven. After admission there was progressive deterioration of all intellectual functions

and complete personality change. Symptoms had first been noted in 1934 at the age of forty-seven. After admission she developed profound speech difficulties, spontaneous laughing and focal neurological signs. After progressive deterioration of all intellectual functions had occurred, she died on October 6, 1942.

Air encephalography revealed moderate dilatation of the lateral and third ventricles especially the left. Subdural air was visible over the convexity on the right and between the hemispheres. Some extracortical air was irregularly distributed (Fig. 3).

At autopsy the brain presented a remarkably



FIG. 2. Case II showing marked dilatation of the lateral ventricles, especially the right, without displacement. A prefrontal mass of air might suggest frontal lobe atrophy and a diagnosis of Pick's disease. However, the gross and microscopic pathologic findings were those of Alzheimer's disease.

eventuating in mutism. During the final stage, she was completely bed-ridden and vegetative, showing a mask-like facies, bradykinesia, rigidity and grasping and sucking reflexes. She died on November 16, 1942.

On April 7, 1939, a pneumoencephalogram revealed marked dilatation of the lateral ventricles especially on the right. There was a mass of air in the prefrontal region (Fig. 2).

At autopsy there was a considerable degree of symmetrical dilatation of the entire lateral ventricular system but no focal lobar atrophy, and microscopic findings were characteristic of Alzheimer's disease.

CASE III. H. J., a female, white, aged fifty-four, was admitted to St. Elizabeth's Hospital on September 12, 1941, because of confusion, disorientation, emotional instability, irritability

normal appearance with no external evidence of cortical atrophy. On section the entire ventricular system was moderately dilated, especially the anterior horns. The microscopic findings were those of Alzheimer's disease.

CASE IV. J. C., a female, white, aged fifty-five, was admitted to St. Elizabeth's Hospital on July 28, 1937, because of extreme agitation. Symptoms of excitability, bulimia, overactivity and confusion had gradually developed since 1929 at the age of forty-two. After admission she was constantly and purposelessly agitated, her speech was voluminous but stereotyped. She became blind and in spite of a voracious appetite her weight fell to 93 pounds before her death on February 2, 1946.

Air encephalography on November, 1941, showed bilateral ventricular dilatation of a

moderate degree more marked on the right. Aside from a small amount of air over the right convexity which may have been subdural, the extracortical pathways were very poorly filled.

At autopsy there was a suggestion of bilateral frontal lobe atrophy, but this was not marked. Microscopically, argentophile plaques were numerous although neurofibrillary cell changes were infrequent. The picture was that of Alzheimer's disease.

CASE V. L. L., a colored woman, aged fifty-seven, was admitted to St. Elizabeth's Hospital on July 31, 1936, because of gradual and pro-

lobe. Microscopically, in addition to the changes characteristic of cerebral arteriosclerosis, there were typical findings of Alzheimer's disease.

CASE VI. A. E., a female, white, aged sixty-five, was admitted to St. Elizabeth's Hospital on May 10, 1940, because of marked impairment of all intellectual functions. The onset had been six years previously at the age of fifty-nine. When admitted she was mute, agitated and untidy and during her hospital stay she developed tremors, grasping, groping and sucking reflexes. Death occurred on January 22, 1942.

An air encephalogram on July 23, 1940, re-



FIG. 3. Case III showing moderate dilatation of the lateral and third ventricles. A considerable amount of subdural air is visible and there is also some increase in the extracortical markings. Microscopic findings were those of Alzheimer's disease.

gressive mental deterioration which had first been noted as unusual forgetfulness seven years previously at the age of fifty. Speech became meager, she was disoriented and apathetic and displayed gross memory defects. Deterioration progressed to a mute vegetative stage which persisted until she died suddenly on August 6, 1941.

Air encephalography on October 30, 1936, revealed marked dilatation of the lateral ventricles, more marked on the left and an absence of air over the convolutions.

At autopsy, there was very marked dilatation of the entire ventricular system, more pronounced on the left and especially in the posterior and inferior horns. There was considerable arteriosclerotic change in the cerebral arteries and an old infarct of the left temporal

vealed ventricular dilatation more marked on the left. Little extracortical air was visible except for a small amount at the frontal poles.

Gross examination of the brain revealed no external cortical atrophy. The ventricles were bilaterally dilated, more so on the left. The left temporal cortex was only 2 mm. thick with almost complete disappearance of subcortical white matter. Microscopically the findings were those of Pick's disease.

CASE VII. D. B., a female, white, aged forty-seven, was admitted to St. Elizabeth's Hospital on March 26, 1940, because of the gradual onset two years previously of impairment of judgment, carelessness and untidiness, bulimia, polydipsia and urinary incontinence. Memory was relatively retained but she lost the ability

to write and calculate. After hospitalization she lost ground steadily and progressively. In May, 1940, she developed continuous myoclonic tremors localized in the right buttock and thigh. Focal neurological signs appeared, and she became mute, bedridden and vegetative. During the final period there were grasping and groping reflexes, periods of spontaneous laughing and crying and complete loss of contact with the outside world. After an episode of hyperpyrexia and status epilepticus, she died on July 30, 1942.

Air encephalography with the removal of 270 cc. of spinal fluid revealed enormous dilata-

memory. After admission he was described as being agitated, depressed and confused. He became increasingly untidy and dilapidated until death on December 8, 1940, after a febrile illness.

On November 29, 1940, an air encephalogram showed bilateral ventricular dilatation more marked on the right and principally involving the anterior portions of both lateral ventricles. There was a good deal of air visible in the basal cisterns but very little extracortically.

At autopsy the frontal lobes, especially the left, were flattened and atrophic. On section there was marked dilatation of the anterior



FIG. 4. Case VII showing enormous symmetrical dilatation of the lateral ventricles particularly in the anterior portions. Very little extracortical air is visible. Pathologically, there were diffuse areas of partial demyelination of the subcortical white matter.

tion of the lateral ventricles particularly in the anterior portion. Both showed fluid levels. Only a thin shell of brain substance separated the anterior horns from the skull. Very little extracortical air was visible (Fig. 4).

At autopsy there was massive dilatation of the lateral ventricles especially the anterior horns with only a trace of subcortical white matter visible frontally. Microscopically the cortex was relatively well preserved and the principal lesion consisted of extensive demyelination of the subcortical white matter, involving all but the U fibers.

CASE VIII. J. K., a male, white, aged fifty-three, was admitted to St. Elizabeth's Hospital on December 18, 1936, because of defects in judgment, irritability and gross defects in

horns and the third ventricle but very little dilatation of the inferior and posterior horns. Microscopically there were moderate degenerative changes in the cortical neurons especially of the frontal lobes but no changes characteristic of Pick's or Alzheimer's disease were present. The substantia nigra was extensively degenerated.

CASE IX. G. N., a male, white, aged forty-seven, was admitted to St. Elizabeth's Hospital on June 25, 1939, with a history of marked personality change since 1937. His early defects were mainly in the sphere of judgment although intellectual functions were greatly impaired. There has been only slow progression since his admission and he is still up and about although he displays profound mental dilapidation.

An air encephalogram in October, 1940, revealed dilatation of both lateral ventricles especially the left with little extracortical air being visible.

In each of the 9 cases reported, air encephalography revealed dilatation of the lateral ventricles without displacement. Although there was some tendency for the enlargement to be most marked in the anterior portions, whenever the posterior and inferior horns were visualized they were also dilated. In one case the size of the lateral ventricles was approximately the same on the two sides. In 4 the dilatation was greater on the right side, in 4 on the left. The enlargement of the lateral ventricles varied from the slight but definite degree seen in Case IV to the massive amount present in the encephalogram of Case VII where only a thin shell of cortex remained at the frontal pole. The third ventricle could be seen to be dilated in 2 cases.

In 7 of the 9 cases very little extracortical air was visible and no conclusions could be drawn as to the presence or absence of localized or diffuse cortical atrophy. A fairly dense mass of air at the frontal pole was visible in the lateral views in Case II. The encephalograms of Case III showed a considerable amount of diffusely distributed extracortical air. Although a good deal of this probably represents subdural masses the appearance is somewhat suggestive of generalized cortical atrophy.

A comparison of the encephalographic and gross anatomic findings is of interest in the 8 autopsied cases. In general, the actual condition of the ventricles was accurately mirrored in the encephalograms, although there were some minor discrepancies such as the fact that in 2 cases (Cases II and III) what proved to be bilaterally equal ventricular dilatation appeared asymmetrical in the encephalograms while in one (Case VIII) the anatomically smaller ventricle appeared to be the more greatly dilated one in the air study. In 6 cases there was nothing in the encephalographic pictures to indicate gross

lobar atrophy and in 4 of these this was confirmed at autopsy. However, the 2 cases (Cases IV and VIII) which did present some degree of visible atrophy of the frontal lobes were also among those failing to show any appreciable amount of extracortical air. On the other hand, the roentgen appearance of Case II which indicated frontal lobe atrophy and of Case III which suggested diffuse cortical atrophy were both misleading since no gross lobar atrophy was found in either at autopsy. We are unable to offer a reasonable explanation of why so little extracortical air was visible in 6 cases. Since no arachnoidal adhesions were found, there was apparently no blockage of the subarachnoid pathways.

It is thus apparent that this study fails to substantiate the formulation of Flügel as to the value of the air encephalogram in the differential diagnosis of Pick's disease and Alzheimer's disease. The presence or absence of local or diffuse lobar atrophy could not be correctly inferred from a study of the encephalograms and in fact the rather remarkable paucity of visible extracortical air made any interpretation unsatisfactory. The futility of relying on the roentgen ray to differentiate between Pick's disease and Alzheimer's disease is further indicated by a study of the pathologic material. Five of the 8 autopsied cases were diagnosed as belonging to the Alzheimer group. A mass of prefrontal air, suggestive of Pick's disease, was seen in the encephalograms of one of these (Case II) while in only one were there any of the diffuse broad stripes and masses of extracortical air described as typical of Alzheimer's disease. One case (Case VI) was considered, on the basis of the microscopic findings, to be an example of Pick's disease. In this there was no gross lobar atrophy and on encephalography very little extracortical air was seen and certainly none of the broad confluent masses described by Flügel as characteristic of this condition. Two of the cases (Cases VII and VIII) were pathologically obscure encephalopathies which did not fit into either the Pick's or

the Alzheimer's group. This illustrates the point that the presenile dementias are not synonymous with Pick's and Alzheimer's diseases and that a number of other conditions must be included. Thus, any attempt to differentiate encephalographically between the two may be invalidated by the possibility that the particular case being studied may pathologically belong to neither.

Although air encephalography was of little value in differentiating among the various members of the presenile group, it was very successful in separating the degenerative presenile cases from other conditions such as the functional psychoses and space taking lesions. The picture of uniform or asymmetrical ventricular dilatation without displacement was constantly present and was of considerable value in confirming the clinical impression in all of the cases.

SUMMARY AND CONCLUSIONS

1. The literature on the pneumoencephalographic findings in the presenile dementias has been reviewed.

2. Nine cases belonging to this group in all of which air encephalograms were performed are presented. Eight of these came to autopsy and the pathologic and encephalographic findings are compared and the results are analyzed.

3. Uniform or asymmetrical ventricular dilatation without displacement was found in every case and is the characteristic pneumoencephalographic appearance in the presenile dementias.

4. The appearance of the extracortical pathways is of little or no value in distinguishing between Pick's disease and

Alzheimer's disease. Reasons for this are discussed.

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REFERENCES

1. BENEDEK, L., and LEHOCZKY, T. Clinical recognition of Pick's disease; report of 3 cases. *Brain*, 1939, 62, 104-122.
2. BOUTON, S. M., JR. Pick's disease: clinicopathologic case reports. *J. Nerv. & Ment. Dis.*, 1940, 91, 9-30.
3. BUMKE, O., and FOERSTER, O., Editors. Presenile Demenzerkrankungen. In: *Handbuch der Neurologie*. Vol. VII, Part 2, pp. 374-375, J. Springer, Berlin, 1936.
4. CRITCHLEY, M., and others. Discussion on mental and physical symptoms of presenile dementias. *Proc. Roy. Soc. Med.*, 1933, 26, 1077-1091.
5. FLÜGEL, F. E. Die Encephalographie als neurologische Untersuchungsmethode. *Ergebn. d. inn. Med. u. Kinderh.*, 1932, 44, 327-433.
6. FROMENTY, L. L'Encéphalographie dans la maladie de Pick. *Ann. méd.-psychol.*, 1939, 97, pt. 2, 64-71.
7. JARVIS, G. In: Kaplan, Oscar J., Editor. *Mental Disorders in Later Life*. Stanford University Press, 1945.
8. LEMKE, R. Ein Beitrag zum Krankheitsbild der Pickschen Atrophie. *Arch. f. Psychiat.*, 1934, 101, 623-636.
9. McMENEMEY, W. H. Critical review; dementia in middle age. *J. Neurol. & Psychiat.*, 1941, 4, 48-79.
10. MALAMUD, N., and BOYD, D. A., JR. Pick's disease with atrophy of temporal lobes. *Arch. Neurol. & Psychiat.*, 1940, 43, 210-222.
11. NICHOLS, I. C., and WEIGNER, W. C. Pick's disease—specific type of dementia. *Brain*, 1938, 61, 227-249.
12. ROMANO, J., and MILLER, W. C. Clinical and pneumoencephalographic studies in pre-senile dementia. *Radiology*, 1940, 35, 131-137.
13. ROTHSCHILD, D., and KASANIN, J. Clinicopathologic study of Alzheimer's disease. *Arch. Neurol. & Psychiat.*, 1936, 36, 293-321.



ROENTGENOLOGICAL ASPECT OF SARCOIDOSIS

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SARCOID lesions of specific organs were thought to be separate disease entities and were described under various names depending on their localization. Greater experience, however, led to recognition of these entities as a generalized disorder affecting the skin, lymph nodes, uveal tract and parotid gland, lungs, and skeletal system. Recent observations tend to show that visceral organs are perhaps more frequently involved.

Sarcoidosis presents clinical features of a chronic infectious granuloma. The constitutional symptoms are rarely severe, but the disease persists often for years; successively more organs become affected, and occasionally spontaneous healing occurs after one or more relapses. The definite diagnosis of sarcoidosis depends almost entirely on the characteristic histopathological findings. The lesions consist histopathologically of tuberculoid accumulations of epithelioid cells frequently surrounded by a thin layer of lymphocytes. Within the epithelioid follicles occasional giant cells of the Langhans type are seen. Necrosis and caseation are absent, although single epithelioid cells may show some slight necrobiotic changes; exudative features and polymorphonuclear cells are absent. It is interesting to note that in the United States the disease is observed much more frequently in the colored than in the white race. The reason for this does not appear clear since the disease is not at all rare on the Continent.

We shall discuss only the roentgenological aspects of sarcoidosis, and refer the reader to a rather extensive literature dealing with other considerations of this problem.

The pulmonary lesions were first described in 1915 by Kuznitzky and Bitthorf; Jüngling described the skeletal changes associated with sarcoidosis in 1919 and

again in 1928 and considered them as osteitis tuberculosa cystoides. The phalanges, metacarpals, and metatarsals are the usual sites of involvement. Since then, the roentgenologic characteristics of the disease have been repeatedly described in the American and foreign literature.

Most writers concerned with this subject emphasize the variability of the roentgenological findings. There are great individual differences in the distribution, extent, and character of the lesions. This—it is felt—is due in a large measure to the fact that they represent different stages of evolution of the disease. Thus the outstanding roentgenological features observed in the early stage may become superseded by other changes during the subsequent phases of regression and progression. The relatively asymptomatic course of sarcoidosis, of which the roentgenologic findings are often the first evidence, makes it difficult to observe early intrathoracic alterations. In many cases, the process is well advanced when the patients are first seen. Extended observation, however, permits one to follow the evolution of the thoracic lesions through successive stages of development. These observations demonstrate rather convincingly the fluctuations in the course of the disease. While new lesions may appear at any time, the older ones do not always remain stationary. They do show quite often evidence of regression or a change in their morphological characteristics. Not infrequently, all phases of the disease are demonstrable on a single roentgenogram. One finds enlargement of the mediastinal nodes, miliary infiltration, areas of fibrosis, and confluent areas of patchy infiltration. A discussion of the roentgenological features of intrathoracic sarcoid manifestations must, therefore, consider the whole course of the disease rather than stress the indi-

vidual changes varying with the developmental phase of the disease.

Enlargement of the intrathoracic lymph nodes is an outstanding feature of sarcoidosis. The mediastinal and tracheobronchial nodes are usually involved. This results in a striking enlargement of the mediastinal shadow and a more or less marked prominence of the lung roots. The bilateral, frequently symmetrical, enlargement of the nodes ranging from moderately prominent mediastinal or hilar shadows to large "tumor masses" extending far into the lung fields causes remarkable roentgenological appearances. Although it is true that bilateral involvement is exceedingly common in some instances, unilateral lymphadenopathy has been observed. The enlarged nodes do not seem to affect significantly adjacent structures. One does not ordinarily find evidence of pressure on large vessels, the trachea, or esophagus. We did, however, observe a traction diverticulum in one case of mediastinal adenopathy due to sarcoidosis. The intrathoracic nodes show a definite tendency to spontaneous regression. This is sometimes so marked as to cause almost complete disappearance of the nodes. The mediastinal adenopathy has only too often been the cause of diagnostic errors; it was commonly misinterpreted as a lymphoblastoma, and the correct diagnosis was arrived at only after histopathological studies of peripheral nodes revealed sarcoidosis. The disproportion between the extensive anatomical changes and the paucity of clinical symptoms deserves special emphasis as an aid in proper evaluation of the roentgenological manifestations of this disease. At least this has been our experience in the Army where sarcoidosis is usually detected during routine examinations of the chest.

The pulmonary manifestations of sarcoidosis are not pathognomonic per se. They are rarely uniform, and no single type of infiltration can be definitely attributed to an early or late phase of the disease. During the intermediate stages of the disease any one or any combination of the commonly

distinguished groups of infiltration can occur. Although sarcoidosis usually affects the pulmonary parenchyma bilaterally, there are cases with unilateral involvement on record. The infiltration may show a diffuse widespread distribution, or it may be limited in scope, confined to the roots of the lungs or the basal portions of the lung fields. Pulmonary changes are occasionally seen without concomitant enlargement of the mediastinal or tracheobronchial nodes. Of course, one cannot state definitely that these nodes were not enlarged in an earlier stage of the disease and, when absent, had regressed to a more normal size.

Reisner distinguished three main types of infiltration associated with sarcoidosis: (1) diffusely disseminated small nodular infiltration; (2) diffuse or localized peribronchial fibrous infiltration, and (3) coalescent, patchy infiltration.

The diffusely disseminated infiltrates consist of discrete, small, nodular foci resembling in appearance and distribution those observed either in acute miliary or in chronic forms of hematogenous tuberculosis. Sometimes the individual nodules, which occur in the interstitial lymphoid tissue of the pulmonary parenchyma, attain a larger size possibly due to coalescence of smaller foci. The lesions may be distributed uniformly throughout both lungs, or they may be confined to the parahilar or basal segments of the lungs.

The diffuse or localized infiltrations of a linear or strand-like character seem to follow the distribution of the bronchovascular pattern and are characterized roentgenologically by prominent root trunks and peripheral markings. A combination of the disseminated nodular form and the linear "peribronchial-perivascular" pattern occurs not infrequently.

Coalescent patchy densities are usually observed alongside widespread peribronchial-perivascular and nodular infiltrations. Lesions of this type can be widely distributed, but they are usually more frequent in the mid-zones and basal segments.

The various types of pulmonary lesions

observed in sarcoidosis represent only manifestations of different stages of evolution. It is only to be expected that, in a disease of such a chronic nature with frequent remissions and relapses, there should be transitions from one type of infiltration into another and that any combination of infiltrations should be observed concurrently. A complete absorption of some areas of infiltration is seen almost invariably in cases remaining under prolonged clinical observation. The developmental cycle of pulmonary sarcoidosis is difficult to determine, but perhaps a general pattern as described by Reisner can be recognized. According to him, the disseminated nodular forms are most likely associated with an early stage of the disease. The more bizarre forms such as the linear interstitial fibrotic type and the conglomerate densities can best be regarded as expressions of an intermediate or late phase. These latter changes are probably irreversible.

The disseminated nodular forms are of a reversible nature as they show a definite tendency to spontaneous regression. In some cases the regression is only partial; while certain areas of infiltration show resolution, other portions of the lung fields exhibit little or no change.

A discussion of thoracic manifestations of sarcoidosis must also include a consideration of the cardiovascular system. The myocardium and pericardium have been occasionally affected by this disease. Clinically, arrhythmias, conduction defects, cardiac enlargement, and right cardiac failure have been observed. Pathological examinations revealed in several instances invasion of the myocardium or pericardium by sarcoid. Right cardiac enlargement was demonstrated in one of our own cases which showed also significant electrocardiographic changes. It is perhaps reasonable to assume that even in absence of direct cardiac invasion the chronic peribronchovascular fibrosis may obstruct the normal pulmonary circulation and result in a chronic cor pulmonale.

Skeletal changes are said to occur rela-

tively frequently (approximately 20 per cent) in association with sarcoidosis. We did not observe alterations in our series of cases. The bone lesions—when present—are so characteristic that they may be regarded as practically pathognomonic for sarcoidosis. The lesions, resembling small cysts, are found in the phalanges of the fingers and toes. Two main types of bone lesions can be distinguished: (1) the circumscribed form which consists of sharply defined "punched-out" areas of rarefaction, circular or oval in shape, usually located within the cancellous portion of the bone without evidence of bone reaction, and (2) the diffuse form which produces a reticular appearance of the bone due to multiple small irregular areas of rarefaction. In this type, large portions of bone are usually involved with frequently resulting alteration of its size and shape. The shaft is widened and the cortex is thinned out.

Nineteen cases of sarcoidosis were observed by us during the last three years; all of them occurred in members of the Armed Forces. Some of them have served for several years and saw overseas duty. We would like to report briefly 4 cases representative of the disease. In one case there was involvement of the lacrimal glands, skin, and the lungs.

REPORT OF CASES

CASE 1. A twenty-one year old Negro male was admitted to the hospital from the Separation Center where a roentgen examination of the chest revealed an enlargement of the mediastinum.

The patient had no complaints and was in good health throughout his service in the Army. The family history was not contributory. The physical examination was essentially negative. Laboratory examination showed normal red and white blood cell counts, normal sedimentation rate, and a normal serum protein with an AG ratio 2:1. A tuberculin test was negative.

Roentgen examination of the chest showed a bilateral enlargement of the paratracheal and parabronchial lymph nodes and a very discrete

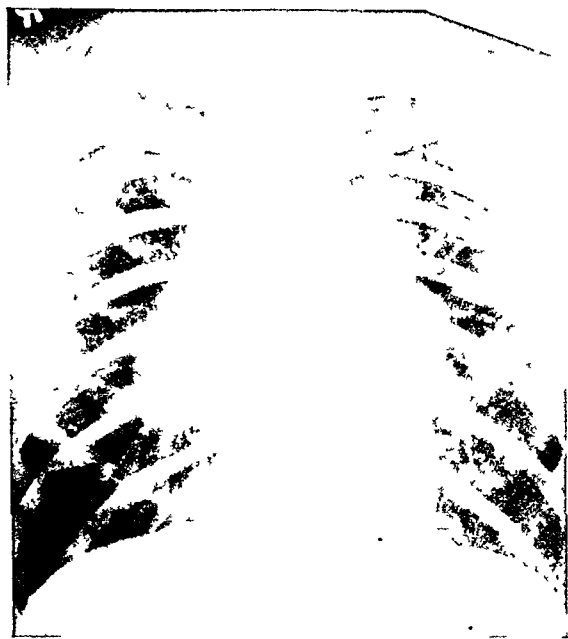


FIG. 1. Case 1. The tracheobronchial and mediastinal nodes are enlarged. There is a miliary infiltration in the right infraclavicular region.

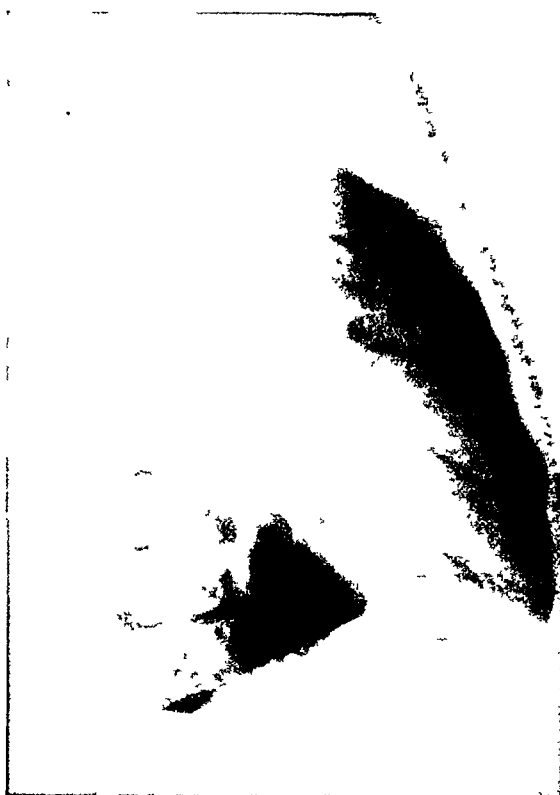


FIG. 2. Case 1. Lateral view demonstrating the mediastinal adenopathy.



FIG. 3. Case 11. The tracheobronchial and mediastinal nodes are enlarged. Discrete miliary infiltration in both lower lung fields.



FIG. 4. Case 11. Some regression of the original adenopathy. The pulmonary infiltration is more extensive; it is now coarser, fibronodular in character.



FIG. 5. Case II. The pulmonary infiltration is fairly generalized. At the right base it is patchy in character and coalescent.

miliary infiltration in the infraclavicular portion of the right lung field. A diagnosis of mediastino-pulmonary sarcoidosis was made which was verified by biopsy of a peripheral lymph node.

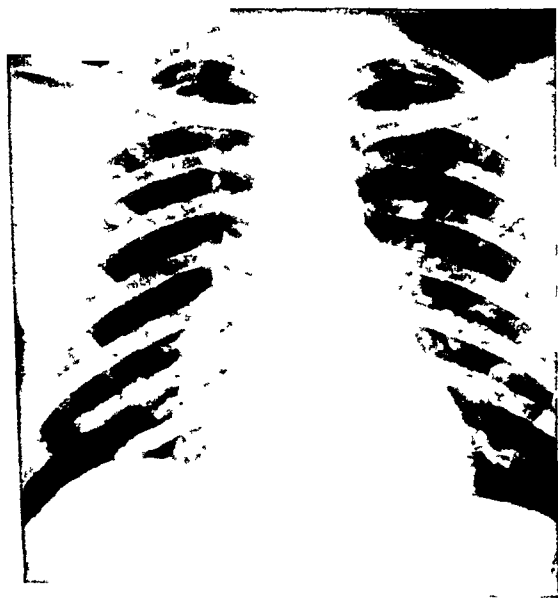


FIG. 6. Case III. Fairly diffuse fibronodular infiltration in both lung fields. The mediastinal nodes are not significantly enlarged.

CASE II. A nineteen year old Negro male was admitted to the hospital in December, 1946. The patient was referred from the Separation Center where a roentgen examination of the chest disclosed a mass in the mediastinum.

Except for the usual childhood diseases, there was no history of illness in the past. The family history was non-contributory. The patient was in good health at the time of admission. Physical examination was essentially negative. There was no peripheral adenopathy. Laboratory examination showed normal red and white blood cell counts. The differential count was 73 per cent neutrophils, 18 per cent lympho-



FIG. 7. Case III. Recent exacerbation with coalescent patchy infiltration at the right base.

cytes, and 9 per cent eosinophiles. The serum protein was 7.5 gm. (albumin, 4.9 gm., globulin, 2.6 gm. and AG ratio 1.9). The sedimentation rate was 15 mm. per hour. The tuberculin test was negative.

Roentgen examination of the chest showed bilateral enlargement of the mediastinal nodes and a discrete miliary infiltration in both lower lung fields. During three months of observation the mediastinal nodes regressed moderately, but the infiltration had extended farther and became more coarsely nodular in character.

A biopsy of a cervical lymph node revealed sarcoidosis.

CASE III. A twenty year old Negro male sergeant was admitted to this hospital with

numerous "nodular swellings" over the entire body and a generalized lymphadenopathy.

The family and past history were not contributory. The patient appeared in no distress; there was no fever, pain, or cough. The skin lesions, which appeared approximately seven months prior to admission to the hospital, showed no significant change in size, consistency, or color since the time they were first observed. The patient was returned to the

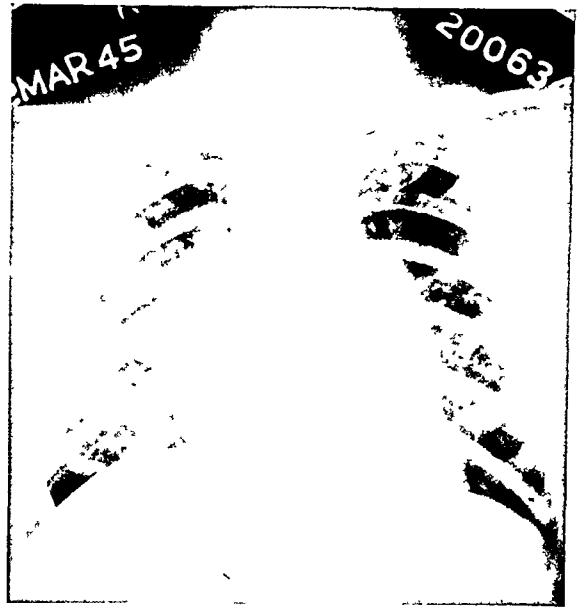


FIG. 9

over seven months showed some regression of the pathologic process in the right lower lung field.

A biopsy of a skin lesion and a cervical node confirmed the clinical and roentgenological diagnosis of sarcoidosis.

CASE IV. A twenty-five year old white male master sergeant was admitted to the hospital because of chills and fever of about four weeks' duration.



FIG. 10

FIG. 8-14. Case IV. Series of roentgenograms taken within a fourteen month period, showing the fluctuating character of the disease with regressions and exacerbations and a change of the cardiac shadow suggestive of cor pulmonale.

United States for separation from the Armed Forces.

Physical examination showed an enlargement of the lacrimal glands and hypertrophy of the conjunctivae, ptosis of the eyelids, enlarged cervical nodes, and widely disseminated cutaneous lesions, most numerous on the trunk. The internal organs showed no abnormality.

Laboratory Findings: The red blood cell count was 4.2 million, white blood cell count, 5,300, hemoglobin 80 per cent; the differential smear showed no significant deviation from normal. There was a rather diffuse peribronchial fibronodular infiltration throughout the right lung field and the inner zone of the left lung field. The mediastinal nodes were somewhat enlarged but not significantly so. Observation

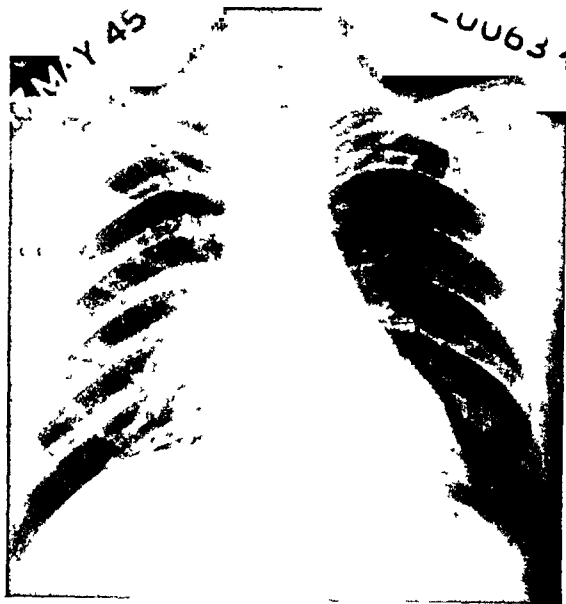


FIG. 11

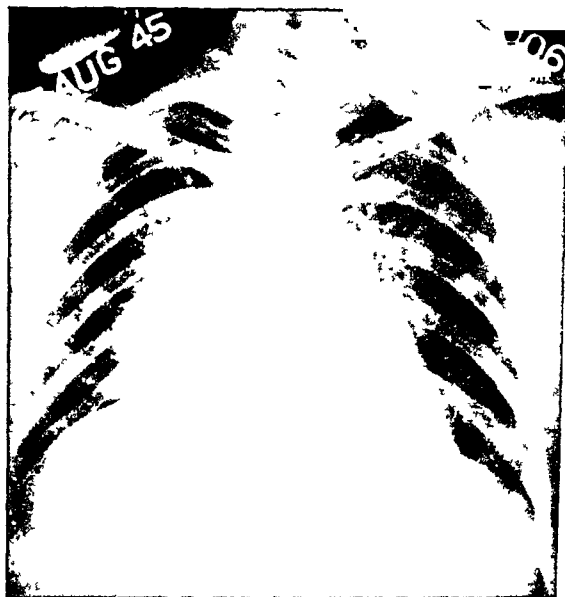


FIG. 12



FIG. 13

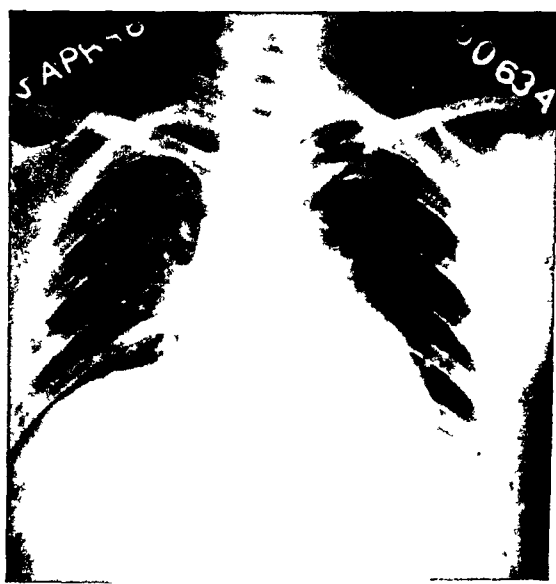


FIG. 14

Family and Occupational History. The patient's mother was a cardiac patient. One of his brothers was an "asthmatic"; two uncles and one grandfather had had tuberculosis. In civilian life the patient had worked as a cleaner and painter of tanks for an oil refinery. At the onset of his illness he had served in the Army for two and one-half years in the capacity of a butcher and a mess sergeant.

Present Illness. About one year before ad-

mission, the patient was hospitalized for a cold. Subsequently, he complained of "heaviness" in his chest. About four weeks before admission to this hospital, he began to have episodes of chills and fever, for which he was briefly observed at another hospital. At that time, the physical examination was negative. The roentgen examination showed well rounded mediastinal masses of increased density along the trachea and the main bronchi. The red

blood cell count was 4.9 million, white blood cell count 8,750; the differential smear revealed 52 per cent neutrophils, and 48 per cent lymphocytes. The sedimentation rate was 38 mm. and later 22 mm. (corrected).

Further observation in this hospital showed complete absence of any significant findings.

Laboratory Examination. The red blood cell count averaged about 4-5 million. The white blood cell count averaged around 4,000. Differential smears showed from 1 to 21 per cent eosinophiles, averaging between 10 and 15 per cent eosinophiles. The lymphocytes varied from 2 to 24 per cent; the monocytes varied from 1 to 3 per cent; hemoglobin was within normal limits. The urine was negative. Sedimentation rate always remained within normal limits. Serum protein on admission was 7.2 gm. per 100 cc., with 5.1 gm. of albumin and 2.1 gm. of globulin. Eight months after admission, the serum protein was 6.5 gm. per 100 cc. with 5 gm. of albumin and 1.6 gm. of globulin. Twelve months after admission, total protein was 6.8 gm. per 100 cc., with 3.6 gm. of albumin and 3.2 gm. of globulin. The Kahn test was negative. Complement fixation tests for coccidioidomycosis were negative in all dilutions. The patient gave no reaction to 0.01 mg. old tuberculin and 1 mg. old tuberculin.

Serial roentgenologic studies of the chest revealed marked enlargement of the mediastinal nodes and a fibronodular infiltration in both lower lung fields. The mediastinal nodes regressed slowly; the pulmonary infiltration showed marked fluctuation, first extending to involve also the upper portions of the lung fields, and later receding with resulting clearing of the left lung field. After a period of regression, new areas of infiltration developed in the hilar regions; the infiltration was of fibrous character. A right cardiac enlargement could also be observed. This exacerbation of the pulmonary involvement was later again followed by a significant remission. The left mediastinal nodes became reduced to almost normal size.

A biopsy of a peripheral node showed changes characteristic of sarcoidosis.

CONCLUSIONS

1. The observation of nineteen cases of pulmonary sarcoidosis confirmed essentially the findings reported in the literature.
2. The patients whom we saw in the

Army showed practically no clinical evidence of disease and were detected usually in the course of routine examinations.

3. The mediastinal and pulmonary lesions show fairly marked fluctuations characterized by regression of the enlarged nodes and dissemination and less conspicuous regression of the pulmonary infiltrations. These may appear as miliary, nodular, and occasionally confluent patchy densities scattered over large areas of the pulmonary parenchyma.

4. There is no definite correlation between the morphologic changes and clinical symptoms produced by them.

5. Absence of significant mediastinal adenopathy does not necessarily rule out pulmonary sarcoidosis or prove that these nodes are free from the disease. A previously existing adenopathy may have simply regressed sufficiently so that it is no longer recognizable.

6. In view of the clinical experiences the prognosis in cases of pulmonary sarcoidosis should always be guarded.

7. A definite diagnosis of sarcoidosis can be established only by a biopsy.

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REFERENCES

1. BERNSTEIN, S. S., and SUSSMAN, M. L. Thoracic manifestations of sarcoidosis. *Radiology*, 1945, 44, 37-43.
2. HORTON, R., LINCOLN, N. S., and PINNER, M. Noncaseating tuberculosis. *Am. Rev. Tuberc.*, 1939, 39, 186-203.
3. KING, D. S. Sarcoid disease as revealed in the chest roentgenogram. *Am. J. ROENTGENOL. & RAD. THERAPY*, 1941, 45, 505-512.
4. LONGCOPE, W. T., and PIERSON, J. W. Boeck's sarcoid (sarcoidosis). *Bull. Johns Hopkins Hosp.*, 1937, 60, 223-296.
5. MEISELS, E. The course of Besnier-Boeck's disease of the lungs in serial roentgenograms. *Am. J. ROENTGENOL. & RAD. THERAPY*, 1940, 44, 564-567.
6. PINNER, M. Noncaseating tuberculosis. *Am. Rev. Tuberc.*, 1938, 37, 690-728.
7. REISNER, D. Boeck's sarcoid and systemic sarcoidosis (Besnier-Boeck-Schaumann disease) *Am. Rev. Tuberc.*, 1944, 49, 289; 437.

HEBERDEN'S NODES

VII. THE ROENTGENOLOGICAL AND CLINICAL APPEARANCE OF DEGENERATIVE JOINT DISEASE OF THE FINGERS*

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A STUDY of the gross and roentgenographic appearance of Heberden's nodes was undertaken because these enlargements of the finger joints are typical examples of degenerative joint disease. Since details of finger joints lend themselves so well to delineation by photographic and roentgenographic investigation it was hoped that such study might contribute to a better understanding not only of Heberden's nodes but also to the general problem of degenerative joint disease which constitutes such a large part of the total arthritic problem.

Heberden¹ wrote, "What are those little hard knobs about the size of a small pea, which are frequently seen upon the fingers particularly a little below the top, near the joints? They have no connection with the gout. . . ." Charcot² stated "the pea-like enlargements . . . are nothing but osseous nodules which exist normally at the head of the second phalanx on the dorsal aspect; only the size of these nodules is considerably increased by the growth of new layers of bone." Modern students employ the term Heberden's nodes to denote degenerative joint disease of the fingers. Heberden's original description included only one stage of the disease which often presents a different appearance varying widely from the above picture. There may be pea-sized knobs. There may also be enlargements or bony overgrowth with flexion and deviation deformity of the terminal phalanges. Heberden's nodes are confined to the terminal joint but are often associated with degenerative joint disease of the proximal interphalangeal joints of the fingers. When this occurs, an erroneous diagnosis

of mixed arthritis is sometimes made because of the generally accepted fallacy that arthritis of the proximal joints is due to rheumatoid arthritis.

Heberden's nodes occur in two different ways. They may arise as the result of direct injury to the terminal interphalangeal joint; in this case they represent a true traumatic arthritis. In such instances one, or at most only two adjacent fingers are involved. At the onset of such traumatic Heberden's nodes, swelling is noted to appear immediately or shortly after a definite and vividly recalled injury. Soreness lasts several days or weeks and the condition becomes stabilized in a few months and remains unchanged for years. The deformity does not extend to adjacent fingers. Such a history is typical in men with one or two enlarged fingers.

Under other circumstances and particularly in women, the enlargements arise spontaneously without history of injury. They begin in one finger and spread in months or years to other fingers. These constitute the so-called idiopathic Heberden's nodes with which this study is principally concerned.

Observation of nearly 7,000 individuals³ revealed that this condition was nearly ten times as common in women as in men, that it was more common in white people than in Negroes and that its incidence was definitely related to age, being rare in young people but affecting about 30 per cent of white women in the ninth decade. It was further demonstrated that the occurrence of this form of degenerative joint disease was strongly influenced by heredity, having been found twice as commonly in the

* From the Departments of Medicine and Radiology of Western Reserve University, School of Medicine at City Hospital, Cleveland, Ohio. Presented before the Mid-Western Conference of Radiology, Cleveland, Ohio, Feb. 14-15, 1947.

mothers and three times as commonly in the sisters of affected women as was to be expected in the general population.⁴ The mode of inheritance seemed to be best explained as dependent upon a single chromosome factor which was sex influenced, being dominant in women and recessive in men.⁵

Little or no attention has been devoted to detailed observation of the roentgenographic changes produced by this disease. The most extensive account so far discovered has been given by Scott.⁶ He has



FIG. 1A. Case 1. Right index finger showing tumor mass over dorsum of terminal joint which was fluctuant, translucent, slightly tender, but not hot.

described the earliest changes as simple narrowing of the joint space. This is later followed by spur formation and misalignment of the terminal phalanx. A more advanced stage is indicated by broadening of the base of the terminal phalanx, increased density of the end of the bone and irregularity of the joint surface.

The present study is based on observations, case histories, photographs and roentgenograms of over 100 patients with Heberden's nodes and material assembled during the course of previous studies on different phases of the disease. Particular emphasis will be devoted to the clinical and roentgenographic appearance of the condition and the time relationships of different stages of the disease. Lateral roentgenograms of the fingers will be emphasized because these have been previously neglected and are largely unknown.

CASE REPORTS

CASE 1. Mrs. C. C., first seen at forty-five years of age because of hypertension, was found to have tender, raised, split pea-sized nodules on the posterior surfaces of the distal phalangeal joints of the fingers of two years' duration. Photograph of the right index finger (Fig. 1A), at the age of forty-seven, shows a tumor mass over the terminal joint which was fluctuant, trans-



FIG. 1B. Case 1. Lateral roentgenogram of right index finger showing bulbous enlargement anteriorly and posteriorly of the distal end of the middle phalanx and spur formation on the dorsal and palmar aspects of the proximal end of the distal phalanx.

lucent, slightly tender but not hot. A diagnosis was made of synovial lesion of the skin, and the cyst was evacuated. Photograph of this entire hand shows enlargements also of the middle and little finger with flexion deformity of the latter. Roentgenogram of the right index finger in lateral view (Fig. 1B) shows definite spur formation on the dorsal and palmar aspects of the distal end of the middle phalanx and from the dorsal aspect of the proximal end of the distal phalanx.

Posteroanterior roentgenogram of the right hand at the age of forty-seven (Fig 1C) shows slight changes only in the index and little fingers. There is decreased joint space and slight spur formation. There is slight condensation of bone along the joint line of the index finger. The joint surfaces are regular.

Six years later, at the age of fifty-three, there were well marked enlargements of all fingers of both hands. Photograph of the right hand then (Fig. 1D) shows the pea-shaped nodules particularly well in the index and middle fingers. A roentgenogram (Fig. 1E) shows marked de-

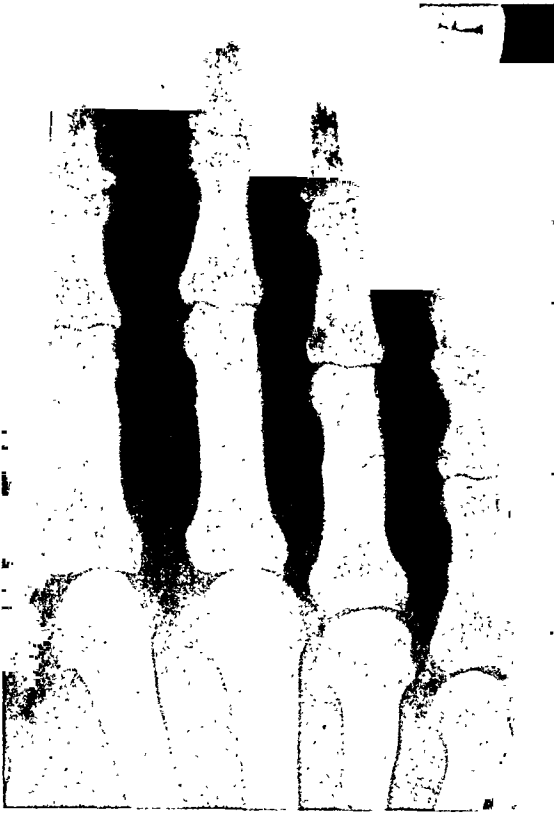


FIG. 1C. Case 1. Posteroanterior view of right hand shows narrowed terminal joint spaces, beginning spur formation and slight bone condensation of index and little fingers.



FIG. 1D. Case 1. Six years later shows pea-shaped nodules on dorsum of terminal joints, particularly well marked in index and middle fingers.



FIG. 1F. Case 1. Lateral views show proximally extending spur formations anteriorly and posteriorly on adjacent ends of terminal and middle phalanges giving the appearance of a ball and socket joint.

FIG. 1E. Case 1. Posteroanterior view of right fingers shows deformities of the terminal joint lines, spur formations with broadening of the lateral diameters of the proximal ends of the distal phalanges. The distal ends of the middle phalanges show an irregular arrangement of the trabeculae producing a foamy appearance.

formity of the joint lines, irregularity of joint space and spur formation with broadening of the lateral diameter of the proximal end of the distal phalanges. The detailed structure of the bone of the distal portion of the second phalanges shows an irregular arrangement of the trabeculae producing a foamy appearance. The proximal interphalangeal and the metacarpophalangeal joints are apparently normal.

Lateral views of the finger joints are seen in Figure 1*F*. The alteration of joint structure is striking. Marked spur formation extending proximally from both dorsal and palmar surfaces of the proximal end of the distal phalanges gives the appearance of the section of a ball and socket joint. There is also spur formation from the distal ends of the middle phalanges. Even the ring finger which is only slightly deformed clinically, in the posteroanterior roentgenogram contains a spur on the dorsal aspect of the distal phalanx.

CASE II. Mrs. E. H., aged forty-two, had no



FIG. 2*B*. Case II. Dorsopalmar roentgenogram shows only slight narrowing of terminal joints of index and ring fingers and small "punched-out" area on radial side of head of the middle phalanx of the ring finger.



FIG. 2*A*. Case II. Dorsal enlargements of transverse ridge type of terminal joints except little finger present for four years.

ticed enlargements of her fingers for four years. Photograph of the right hand (Fig. 2*A*) shows enlargement of all the terminal joints except the little finger. This enlargement takes the shape of a transverse ridge rather than "small pea-shaped nodules." The hand is otherwise normal. A roentgenogram (Fig. 2*B*) shows little or no abnormality. There is narrowing of the ulnar half of the joint space of the index finger and narrowing of the joint space of the ring finger. There is also a small punched out area 2 mm. in diameter on the radial side of the distal end of the second phalanx of the ring finger. The roentgenogram is otherwise normal. A photograph taken sixteen months later is indistinguishable from the one shown. At this time, posteroanterior roentgenograms show only decreased joint space. The lateral roentgenogram (Fig. 2*C*) shows a large spur arising from the dorsal aspect of the proximal end of the terminal phalanx of the ring finger. This spur is large enough to increase the joint surface by about 60 per cent. Very small spurs are

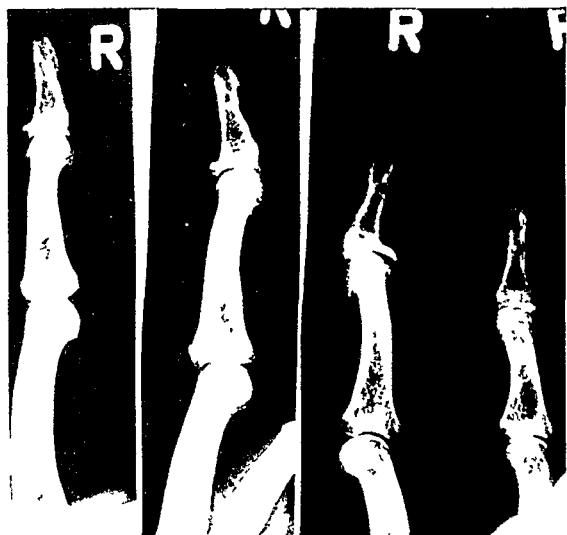


FIG. 2C. Case II. Lateral projection made sixteen months later shows spur formations on proximal ends of terminal phalanges except in little finger. Posteroanterior projection failed to reveal spurs.

seen in the same position of the index and middle fingers and also on the palmar and the dorsal surfaces of the distal end of the middle phalanges. The little finger is normal.

This case illustrates that marked deformities may be apparent clinically in the finger joints with little or no evidence of bone change visible in posteroanterior roentgenograms.

CASE III. Mrs. B. H. was a woman, aged forty-seven, whose fingers had been enlarged for two years. Examination showed considerable enlargement of the terminal joints with flexion deformity of both little fingers, slightly smaller enlargement of the left ring and right middle fingers but little or no change of either index fingers or the left middle or right ring fingers.

Posteroanterior roentgenogram of the right hand (Fig. 3A) shows little abnormality. In the terminal joints the index finger is almost completely normal showing only a very small spur about 1 mm. long on the ulnar side of the proximal end of the distal phalanx. In the middle finger the base of the distal phalanx is definitely broadened, the joint surface here being in-



FIG. 3A. Case III. Dorsopalmar view shows slight changes of spurring of index finger, broadening and narrowing of joint of middle finger, narrowing of joint space of ring finger.



FIG. 3B. Case III. Photograph of right hand forty-two months later shows increase in size of terminal joint of middle, ring and little fingers with flexion deformity of middle finger.



FIG. 3C. Case III. Dorsopalmar view shows progressive changes of spur formation and increased width of the base of the distal phalanges of the middle, ring and little fingers.

creased in density and the joint space is narrowed. The distal end of the second phalanx is not altered. The ring finger shows only decrease in joint space. The little finger shows marked change with broadening of the bone ends, irregularity of joint surface and decrease in joint space.

Photograph of the right hand forty-two months later (Fig. 3B) shows marked increase in size of the terminal joint of the middle, ring and little fingers. There is also flexion deformity of the middle finger. A roentgenogram at this time (Fig. 3C) shows increase in the width of the base of the distal phalanges of the middle, ring and little fingers. The joint surfaces of these fingers show increased density of bone, narrowing or obliteration of joint space, and an irregularity of bone trabeculation of the distal end of the middle phalanges of the middle and little fingers, giving them a foamy appearance. The index finger and the other joints of the hand are normal. A lateral view (Fig. 3D) shows spur formation from the dorsal aspect of the proximal ends of the distal phalanges most marked in the middle but present in the ring and little finger and absent from the index fingers. Spur

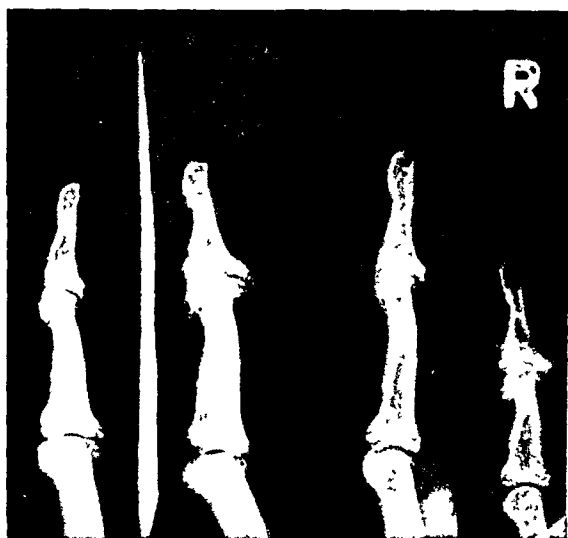


FIG. 3D. Case III. Lateral views show better the degree of spur formations and narrowing of the space of the terminal joint of the middle, ring and little fingers. Spurs are present on the middle as well as the distal phalanges.

formation is also seen from the distal ends of the middle phalanges of all but the index finger.

In this case, marked advancement of the arthritic process was seen over a period of forty-two months. This woman had no other significant arthritis.

CASE IV. Mrs. E. P. was a woman aged sixty-two, with Heberden's nodes for fourteen years. Photograph of the right hand (Fig. 4A) shows marked enlargements of all terminal joints with flexion deformity. There is in addition obvious enlargement and ulnar deviation of the proximal interphalangeal joint of the index finger. A posteroanterior roentgenogram (Fig. 4B) shows marked enlargements of all distal interphalangeal joints with bulbous swelling and foamy rarefaction of the distal ends of the second phalanges. The joint line is obliterated or obscured by the flexion deformity especially marked in the index and middle fingers. The proximal joints are also affected in this case. The joint spaces are normal and the joint surfaces are not distorted but the bones are broadened, the proximal ends of the middle phalanges extending much beyond the distal ends of the proximal phalanges. There is also foamy distortion of the trabeculae here.

The lateral views (Fig. 4C) show large spurs from the dorsal surfaces of the base of the distal phalanges of the index, middle and ring fingers,



FIG. 4A. Case IV. Photograph of right hand shows marked enlargements of all terminal joints with flexion deformity. Also there is enlargement and ulnar deviation of the proximal interphalangeal joint of the index finger.



FIG. 4B. Case IV. Posteroanterior view shows roentgenographic appearance of enlargements of terminal joints with bulbous swellings and foamy trabeculation of distal ends of second phalanges.

slight enlargement of the distal ends of the middle phalanges. A large spur is also seen extending from the dorsal surface of the proximal end of the middle phalanx of the index finger. No other spurs are seen here in the middle, ring

or little fingers. The thumb shows no change of the proximal end of the distal phalanx but there are large spurs extending from the dorsal and the palmar surfaces of the distal end of the proximal phalanx.



FIG. 4C. Case IV. Lateral views show the extent of spur formations on adjacent ends of middle and distal phalanges of the index, middle and ring fingers. The proximal phalanx of the thumb and the proximal end of the middle phalanx of the index finger are also involved.



FIG. 5A. Case v. Photograph showing enlargements and angular deformities of the proximal and distal joints of all the fingers.

CASE v. Mrs. M. R. was a woman aged seventy-one, who noticed swelling of her fingers twenty-five years before, involving both the distal and the proximal interphalangeal joints. Photograph (Fig. 5A) shows enlargement and the deformity of all the fingers. This is particularly marked in the proximal and distal phalanges which in the index and middle finger are flanked by substantial spurs (Fig. 5B) which extend beyond and curve proximally as though to enclose the distal ends of the middle phalanges. The distal ends of middle phalanges show marked bulbous enlargement with the same foamy disarrangement of the distal ends of the middle phalanges which has been described before. The interphalangeal joints are also markedly enlarged with the same broadening of the base and overhanging spurs of the proximal end of the middle phalanges and a similar foamy disarrangement of trabeculation of the distal ends of the proximal phalanges. The metacarpophalangeal joints appear to be completely normal. Lateral roentgenograms

(Fig. 5C) show marked spur formation from the distal phalanges and marked increase in



FIG. 5B. Case v. Posteroanterior roentgenogram shows the marked spur formations, bulbous enlargements and foamy disarrangement of the adjacent ends of bones forming the proximal and distal joints. Soft tissue thickening around the joints is also shown.

diameter of both bones constituting the proximal interphalangeal joints. A roentgenogram of the thumb shows marked bony enlargements which would not be suspected from the photograph.

DISCUSSION

Idiopathic Heberden's nodes are generally considered to be typical examples of degenerative joint disease. It has been variously stated that they are pathogno-

finger, was least susceptible of all, being involved in only 50 per cent of the cases. The thumbs were so rarely deformed grossly that they were ignored in the tabulation.

Involvement of the proximal interphalangeal joints was encountered much more frequently than had been anticipated. A review of roentgenograms and photographs of 91 sets of hands revealed obvious de-



FIG. 5C. Case v. Lateral roentgenogram demonstrates better the extent of spur formation and the increased diameter of the proximal interphalangeal joints. Thumb changes show better than would be suspected from photograph.

monic of the disease, or that they establish the diagnosis. Certainly their presence is not necessary to establish that diagnosis. Degenerative joint disease is a disease which lends itself to protean manifestations and it shows marked variations from case to case as to the number and variety of joints involved as well as to the wide differences in the degree of such involvement. Even in advanced cases of Heberden's nodes uniform involvement of all the fingers is rare, individual joints being only mildly altered or even spared entirely. A tabulation of the involved fingers in 150 women with Heberden's nodes showed only 75 per cent of the fingers of the right hand and 72 per cent of the fingers of the left hand are affected. Fifty-five per cent of the ring fingers were involved. The ring finger of the left hand, the wedding ring

generative joint disease of the proximal interphalangeal joints in 36 patients, or 40 per cent of the cases. Arthritis of proximal interphalangeal joints of the fingers is not pathognomonic of rheumatoid arthritis as has so often been fallaciously stated.

The relationship of Heberden's nodes to other degenerative joint disease has been previously considered. In a detailed analysis of 94 women with Heberden's nodes,⁷ it was found that 12 of them had definite degenerative joint disease involving other joints. In 19 other instances there were minor joint complaints without definite arthritis and 34 cases had crepitus of the knees. This was in striking contrast to the conditions found in a comparable control series of 109 women of about the same age distribution. They had only 3 instances of joint disease, no recorded minor joint com-

plaints and only 25 cases of crepitus of the knees. The conclusion is inescapable that Heberden's nodes tend to be associated with degenerative joint disease of other joints.

Degenerative joint disease is considered to depend primarily upon degeneration, erosion and finally a wearing away of joint cartilage, followed secondarily by condensation of bone along what had been the subchondral bone plate and at the edges of the joint where spurs are formed. Our roentgenographic studies support this supposition. The earliest observed roentgenographic change is decrease of joint space indicating loss of cartilage. There is later thickening of the bone of the joint surface, evidence of condensation of the subchondral plate and finally spur formation. There is marked distortion of joint surfaces producing serrated or notched surfaces resulting in poor approximation of the opposing joint surfaces. Definite punched out areas suggesting ulcerations of the joint surfaces are seen best in the tangential view at the periphery.

Spur formation is best seen in lateral views. The largest ones seem to arise from the dorsal aspect of the proximal end of the distal phalanx quite near to and seeming to produce an extension of the joint surface itself. Such spurs, if small, may seem to extend only posteriorly and proximally. They arise from what may be assumed to be the attachment of the extensor tendon. Similar but smaller spurs arise from the palmar surface corresponding to the attachment of the flexion tendons. Other bone proliferation does occur, however, quite independent of tendinous attachments. These are seen as extensions of the joint surface of the distal end of the middle phalanges. This is a protrusion proximally from the dorsal and palmar surfaces. In general, these are larger in the palmar surface. When the distal end of the middle phalanx has become greatly enlarged and bulbous this bony spur becomes almost a shelf-like protrusion. Similar changes may be seen in the proximal interphalangeal joints when they are affected.

If examples of Heberden's nodes are observed in order of increasing severity, it will be noted that bone structure suffers progressive alteration, particularly marked at the distal end of the middle phalanx. When viewed in a true posteroanterior projection this is normally shaped like a truncated cone, the sides and top of which are slightly concave. Trabeculation is arranged in a very orderly fashion, the bone elements being about equally spaced and arranged in a longitudinal direction. As the disease progresses the distal end of the middle phalanx loses its truncated cone appearance but becomes gradually widened, blown out and bulbous in shape, more nearly resembling a sphere and the bone trabeculations become very irregular in density, distribution and direction. Numerous instances have been observed of cyst-like areas of rarefaction near the distal end of the middle phalanx, sometimes apparently not communicating with the bone surface. These are often suggestive of gout. Such areas of punched-out cysts seem to be temporary because they are often no longer visible in subsequent roentgenograms.

Distortion of bone structure even at some distance from the joint surface is not uncommon in degenerative joint disease. Notable examples are seen in the hip where the head of the femur becomes mushroomed, broadening out in all diameters with the production of overhanging lips about the edges. At the same time the neck of the femur becomes shortened and the angle of the neck on the shaft of the bone becomes more obtuse. The acetabulum changes shape also to accommodate the distorted head. This is the typical picture of *malum coxae senilis*.

Review of the study material reveals the fact that soft tissue changes constitute an important factor of the clinical entity of Heberden's nodes. The most striking of these are cystic formations illustrated in extreme degree in Case I. At least three other such cysts, though not so large, had been opened in our series over joints where

Heberden's nodes subsequently developed. They contained a colorless, gelatinous acellular, amorphous material. This or a similar condition has been described by Gross⁸ as recurring, myxomatous, cutaneous cysts of the fingers and toes. According to Gross they represent a degeneration of tendon. Excision is useless because the lesions invariably recur. He believes radiation therapy gives the best hope of permanent relief. He did not note the subsequent development of Heberden's nodes or degenerative joint disease. Experience in our series indicates that such cysts are definitely related to Heberden's nodes.

Soft tissue changes are responsible for enlargement of the finger joints in cases where no distortion and little or no involvement of bone is seen either in posteroanterior or lateral roentgenograms. This is best demonstrated in the early stage of Case II. There is marked enlargement in the shape of a transverse ridge across the dorsum of the joint but the roentgenogram shows only narrowing of joint space. This feature of degenerative joint disease is often apparent in larger joints such as the knee which show a boggy thickening of the synovial tissue producing villous arthritis of the knee.

Cystic nodules in the tendinous attachments, spur formation along tendons, swelling of soft tissue about the joint and disarrangement of bone structure deep in the subchondral spaces all indicate that degenerative joint disease is more than simple deterioration of cartilage and that it involves many structures and areas at even greater distances from the joint surface than had heretofore been supposed.

Heberden's nodes are the result of a chronic disease. The changes associated with it arise gradually and they progress at a slow rate. The bone changes seem to be largely irreversible although the tumors of cyst formation and other soft tissue enlargements have been noted to decrease in size from time to time. The size of the joint and its gross appearance is no reliable indication of the bone condition as seen on

the roentgenogram. Case II photographs of the hands taken sixteen months apart were indistinguishable from each other. They showed moderate enlargement of the joints in the form of a transverse ridge across the backs of the joints. Neither flexion deformity nor deviation was apparent. The first roentgenogram shows only narrowing of the joint space of the index and ring finger with one small punched out area 2 mm. in diameter. A roentgenogram sixteen months later shows only slight change from the previous one, the joint spaces being slightly smaller than before.

In Case III marked progress of the bone deformities were observed in forty-two months. At the first examination the roentgenograms showed the index finger to be nearly normal. The ring finger showed only decreased joint space. The middle finger showed no definite narrowing of the joint space with increased density of the joint surface and increased width of the joint. The little finger shows the same change. Forty-two months later the bases of the distal phalanges of the middle, ring, and little fingers have become definitely broadened. There is further narrowing of the joint spaces and increased density of bone in these fingers. Marked change in bone trabeculation with the appearance of the foamy structure of the end of the middle phalanges is now marked.

In Case II, the first posteroanterior roentgenogram shows only slight changes in the index and little fingers with narrowing of the joint space and slight condensation of bone. Roentgenograms taken again six years later show marked deformity of the joint lines, irregularity of the joint space and spur formation and broadening of the base. The same foamy change in the trabeculae is again noted.

Thus it is found that marked bone changes were seen to occur when fingers with developing Heberden's nodes but only slight bone changes were re-examined in six years and in forty-two months. On the other hand, only slight changes were

noted in Case II in a period of sixteen months.

SUMMARY

Heberden's nodes are enlargements of finger joints due to degenerative joint disease. Review of a series of photographs and roentgenograms reveals the following noteworthy features of Heberden's nodes.

1. Their appearance may range widely from Heberden's original description of "hard knobs about the size of a small pea."

2. They may start as a fluctuant swelling, a myxomatous subcutaneous cyst or a synovial lesion in the skin but develop from these to large bony deformities.

3. Roentgenograms reveal enlargement of the ends of the bones with distortion of joint space and irregularity of the joint surface. Large spurs develop from the attachments of the flexor and the extensor tendons to the terminal phalanx. Such spurs seen only in lateral views have been heretofore largely overlooked.

4. The distal ends of the middle phalanges undergo marked change of the bony structure with irregularity and a foamy arrangement of the trabeculae.

5. Heberden's nodes, typical manifestations of degenerative joint disease of the terminal finger joints, are sometimes associated with degenerative joint disease of the proximal interphalangeal joints. Such association was noted in 40 per cent of our cases.

6. Degenerative joint disease involves periarticular soft tissue, tendinous attachments and subchondral marrow spaces as well as the joint cartilage and the immediately underlying bone.

7. The joint changes which occurred during definite periods of time have been described.

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REFERENCES

1. HEBERDEN, W. Commentaries on the History and Cure of Diseases. Second edition. T. Payne, London, 1803, p. 148.
2. CHARCOT, J. M. Clinical Lectures on Senile and Chronic Diseases. The New Sydenham Society, London, 1881, 307 pp.
3. STECHER, R. M. Heberden's nodes; incidence of hypertrophic arthritis of the fingers. *New England J. Med.*, 1940, 222, 300-308.
4. STECHER, R. M. Heberden's nodes. Heredity in hypertrophic arthritis of the finger joints. *Am. J. M. Sc.*, 1941, 201, 801-809.
5. STECHER, R. M., and HERSH, A. H. Heberden's nodes; mechanism of inheritance in hypertrophic arthritis of the fingers. *J. Clin. Investigation*, 1944, 23, 699-704.
6. SCOTT, S. G. Radiological Atlas of Chronic Rheumatic Arthritis (The Hand). Oxford Medical Publications, London, 1935.
7. STECHER, R. M. Heberden's nodes; their relation to other degenerative joint disease. *Arch. Phys. Med.*, 1946, 27, 409-413.
8. GROSS, R. E. Recurring myxomatous, cutaneous cysts of the fingers and toes. *Surg., Gynec. & Obst.*, 1937, 65, 289-302.



RIGHT PARADUODENAL HERNIA WITH ROENTGEN DIAGNOSIS AND POSTOPERATIVE RECOVERY*

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PARADUODENAL hernias consist of the enclosure of the greater part of the small bowel by the mesocolon through the duodenojejunal junction. They may be right or left sided.

There has been a difference of opinion as to the etiology of this condition with one or two theories being accepted by different investigators. In 1923 Andrews¹ discussed the two types of paraduodenal hernia and described their formation as a congenital anomaly of the development of the peritoneum. In the normal formation of the colon the cecum progresses in a counter clockwise direction from the area of the splenic flexure across the abdomen forming the transverse colon to the hepatic flexure and then downward into the right lower quadrant. Should the cecum proceed more directly into the right lower quadrant it would not lie superior to the small intestine. Then as it lengthened, the small bowel would be caught in the mesentery and enveloped¹² when the mesentery became attached to the right posterior abdominal wall (Fig. 1). According to Andrews¹ this would be the means of formation of a right paraduodenal hernia. The left-sided hernia originates by a similar process. If no rotation should occur, the cecum would lie to the right of the midline in the lower abdomen. Then as it elongates the small bowel would become enveloped in the mesentery of the descending colon. It would therefore lie to the left of the midline with the opening facing to the right (Fig. 1).

The second theory is that advanced by Treitz.²² It was his contention that on occasion a loop of small intestine could project itself into the duodenojejunal junction and that due to changes in the

intra-abdominal pressure a retroperitoneal hernia would result. There have been cases reported that seem to support both theories, with more emphasis being given to that of embryological maldevelopment.

Anatomically, the two types of paraduodenal hernia may be differentiated by the following criteria:

- | <i>Right</i> | <i>Left</i> |
|---|---|
| 1. The sac occupies the right half of the abdominal cavity and lies between the ascending and transverse mesocolon. | 1. The sac occupies the left half of the abdominal cavity and lies between the descending and transverse mesocolon. |
| 2. The opening of the sac is on the left side and opens toward the left. | 2. The opening of the sac is on the right side and opens toward the right. |
| 3. The superior mesenteric artery (or ileocolic artery) lies in the anterior sac wall. | 3. The inferior mesenteric artery lies in the anterior sac wall. |

Left-sided paraduodenal hernia has been found to occur more frequently than right-sided, with about three times as many reported in the medical literature.

A summary of the literature shows that there have been 51 cases of right paraduodenal hernia reported. These include those diagnosed by all means, i.e., at operation, roentgenologically and postmortem. Of those reported only 19 have recovered with 32 operated upon. The age of the patients who recovered from operation varies from twelve to fifty-six years with the greatest number falling between twenty-five to fifty. Eleven out of the 19 were males.

There appears to be slight confusion in the literature as to the number of cases of right paraduodenal hernia reported. Cogswell and Thomas,⁷ and Hodges,¹⁴ in separate reports refer to their cases as the sixteenth with recovery. In Table 1, we have attempted to put the various cases reported with postoperative recovery in their correct chronological order.

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TABLE I

REPORTED CASES OF RIGHT PARADUODENAL HERNIA WITH POSTOPERATIVE RECOVERY

Case No.	Author	Age of Patient yr.	Sex	How Diagnosed	Roentgen Examination
1	Neuman ¹⁹	55	F	Operation	None
2	Carson ⁶	29	M	Operation	None
3	Brown ⁴	49	M	Operation	Reported negative
4	Lower and Higgins ¹⁷	12	F	Operation	None
5	Deaver and Burden ⁸	25	M	Operation	None
6	Flechtenmacher ¹¹	38	M	Operation	None
7	Taylor ²¹	32	M	Operation	Encapsulated appearance of small bowel as if sac enclosed
8	Taylor ²¹	24	M	X-ray	Encapsulated appearance of small intestine
9	Masson and McIndoe ¹⁸	41	M	Operation	Reported negative
10	Dowdle ⁹	24	M	Operation	None
11	Exner ¹⁰	56	F	X-ray	Encapsulated appearance of small bowel; displacement of colon; greatly dilated terminal ileum (oral barium and barium enema)
12	Halliwell ¹³	35	M	Operation	Dilated coils of small intestine bunched together chiefly on the right side of the abdomen
13	Bryan ⁵	18	F	Operation	None
14	Averbach ²	14	M	Operation	None
15	Baumeister and Hanchett ³	21	F	Operation	None
16	Cogswell and Thomas ⁷	49	F	Operation	Dilated loops of small bowel and ptosis of transverse colon (barium enema)
17	Hodges ¹⁴	22	M	Operation	None
18	Lahey and Trevor ¹⁶	47	M	Operation	Postoperative review showed spherical encapsulation of small intestine as though contained in paper bag
19	Lahey and Trevor ¹⁶	17	F	Operation	Reported as redundant duodenal loop. Postoperative review showed abnormal location of jejunum on right side of abdomen; absence of transverse third and ascending fourth portions of the duodenum
20	Reeves, Moran and Jones	28	M	X-ray	Encapsulated appearance of small bowel; dilated small bowel; displacement of colon (oral barium)

Klob¹⁵ reported the first case of right paraduodenal hernia in 1861, and Neuman¹⁹ the first with successful operation. Reviewing all the cases we were able to find only 9 that had roentgenological studies of the gastrointestinal tract. One was a study of the large bowel⁷ which showed a low transverse colon and dilated loops of small bowel. Two^{4,18} reported roentgen studies as negative. The remaining 6 cases showed findings that can be considered good pre-

sumptive evidence of right paraduodenal hernia. However, only 2 cases have been correctly diagnosed preoperatively. Taylor²¹ has received due recognition for the first case of right paraduodenal hernia diagnosed preoperatively. Exner¹⁰ in 1933 reported the second. Both were verified by operation.

CASE REPORT

CASE 1. A twenty-eight year old colored man was admitted to the Medical Service of Duke

Hospital with the complaint of several attacks of abdominal pain over a period of two months. The initial onset of the abdominal pain followed the ingestion of peanuts and an iced drink. This attack was characterized by a sudden, sharp pain in the periumbilical region which gradually became cramping in character and

Physical examination: temperature, 37°C.; pulse, 78; respiration, 18; blood pressure, 110/50. The patient was a moderately well developed and well nourished colored man of approximately stated age. The pertinent physical findings were as follows: small, generalized lymphadenopathy; heart enlarged to the left; protodiastolic murmur loudest in third left interspace. The abdomen was flat without masses or palpable organs.

Laboratory findings showed a normal blood study with two negative blood Wassermann tests. Spinal fluid studies were negative.

Roentgen examination showed the stomach and duodenal bulb to be normal. "There is a peculiar, apparently anatomical disarrangement of the jejunum and upper ileum in that these two sections of the bowel assume an almost perfectly spherical shape in configuration. The small intestinal pattern is perfectly normal, but the intestines have the appearance of being enclosed in a round sac-like structure" (Fig. 2). A diagnosis of malrotation or herniation of the small intestine was made and the former ruled out by the normal position of the cecum and terminal ileum (Fig. 3). A preliminary diagnosis of right paraduodenal hernia was

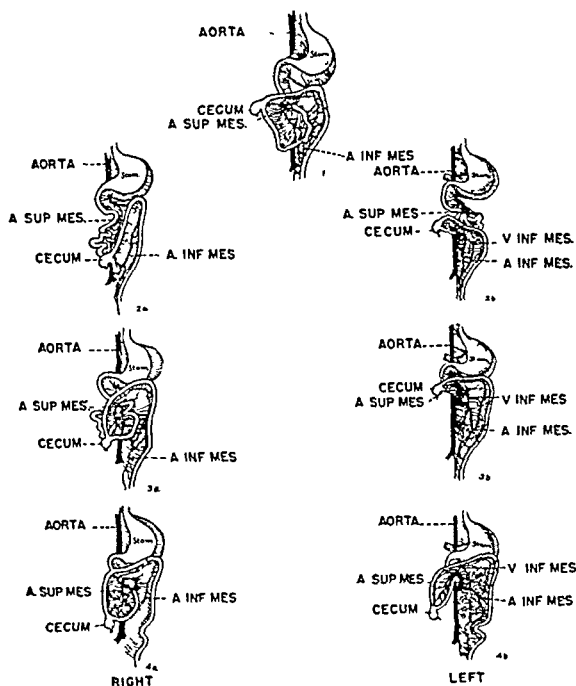


FIG. 1. (Modified from Andrews¹ by special permission of *Surgery, Gynecology and Obstetrics*.) 1, normal rotation of the cecum and small bowel. 2a, 3a, 4a, the cecum proceeds more directly into the right lower quadrant. As the small bowel lengthens it is enveloped by the mesentery, forming a right paraduodenal hernia. 2b, 3b, 4b, when no rotation occurs the elongation of the small bowel causes it to be enveloped by the mesentery of the descending colon. A left paraduodenal hernia is thus formed.

more severe. He vomited food eaten that day without evidence of blood. The initial attack lasted eight hours and was relieved in part by a hypodermic and an enema.

After the onset the patient had five similar attacks which were treated by hypodermics, gastric lavage, and enemas. No history of digestive disturbances between attacks could be obtained.

The family and marital history were non-contributory.

Past history revealed patient's general health to be good. There was a history of inadequately treated syphilis.



FIG. 2. Case 1. Roentgenogram clearly demonstrates (1) sac enclosed appearance of small intestine; (2) loss of continuity of the normal loop of duodenum. The major portion of the small intestine lies to the right of the midline.

made and the patient transferred to the surgical service.

At operation a large retroperitoneal hernia of about two-thirds of the small intestine was found. The entrance to the sac was in the region of the ligament of Treitz through the duodenojejunal junction. The preoperative diagnosis of right paraduodenal hernia was confirmed. The sac was obliterated with interrupted silk sutures and the small intestine returned to its normal position. The patient withstood the operation well and was returned to the ward in good condition.

Postoperative course was uneventful, and there were no further attacks of abdominal pain. A subsequent study of the gastrointestinal tract showed no abnormality in the position of the small bowel (Fig. 4).

That herniation of the small bowel can be present without causing symptoms is seen from the numerous cases that have been found in cadavers and on autopsy examination of patients who died from other causes with no history of abdominal symptoms. In those patients requiring operation the symptoms have varied from



FIG. 3. Case 1. Six hour roentgenogram shows the cecum and terminal ileum in their normal positions. There appears to be displacement of the ascending and transverse portions of the colon by the retroperitoneal hernia. There is gaseous dilatation of the small bowel.



FIG. 4. Case 1. Re-examination of the gastrointestinal tract three weeks after operation shows the small intestine to be restored to normal position.

recurrent right lower quadrant pain to those of complete or partial intestinal obstruction.

The technique of examining patients by the routine barium meal studies should suffice for the diagnosis of paraduodenal hernia, if that routine includes roentgenoscopy of the duodenum and small bowel in the upright and prone positions, as it does in this clinic. If the condition is suspected, interval films from one to six hours and at twenty-four hours, with lateral views, should be included. Small bowel studies are essential for the diagnosis. In those cases in which it is feasible to carry out a diagnostic procedure such as this, certain findings strongly indicate the diagnosis of duodenal hernia. The condition with which it might be most frequently confused is malrotation, but barium enema with study of the position of the cecum and terminal ileum will usually serve to differentiate the two.

When the condition of the patient makes the administration of oral barium and manipulation unwise, then a preliminary

roentgenogram of the abdomen and differential diagnosis would be necessary. A definite diagnosis of paraduodenal hernia cannot be made under these conditions.

In the cases reported as diagnosed preoperatively and in the cases with roentgen studies but not diagnosed before operation, the position of the small bowel appeared typical. The coils of small intestine lay in a spherical, well defined area as though enclosed in a sac. During study with oral barium the third and fourth portions of the duodenum showed obliteration.

Usually the coils of intestine cannot be separated by palpation and pressure. In the prone position the loops of bowel remain encapsulated and do not show normal downward gravitation into the pelvis. There is displacement or distortion of the stomach and/or colon. The immobility of the herniated bowel frequently results in distention by gas, but this may be found in other types of partial or complete intestinal obstruction.

SUMMARY

Although only two cases of right paraduodenal hernia have been previously diagnosed preoperatively, the diagnosis can be made in the majority of cases by roentgen study if the observer is familiar with the features of this condition.

Review of the literature shows almost typical findings in the cases studied. The criteria for diagnosis and theories of their formation are described.

A case of right paraduodenal hernia is presented which was diagnosed preoperatively and successfully operated upon.

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REFERENCES

- ANDREWS, E. Duodenal hernia—a misnomer. *Surg., Gynec. & Obst.*, 1923, 37, 740-750.
- AVERBACH, B. F. Right paraduodenal hernia. *Am. J. Surg.*, 1937, 35, 128-130.
- BAUMEISTER, C., and HANCHETT, M. Right paraduodenal hernia; a case favoring the theory of Treitz. *Arch. Surg.*, 1938, 37, 327-332.
- BROWN, F. R. Right duodenal hernia; a case successfully operated on, fourth recorded recovery. *Brit. J. Surg.*, 1925, 13, 367-376.
- BRYAN, R. C. Right paraduodenal hernia. *Am. J. Surg.*, 1935, 28, 703-730.
- CARSON, H. W. A case of right duodenal hernia. *Proc. Roy. Soc. Med., Surg. Sec.*, 1912, 5, 214-216.
- COGSWELL, H. D., and THOMAS, C. A. Right paraduodenal hernia. *Ann. Surg.*, 1941, 114, 1035-1041.
- DEAVER, J. B., and BURDEN, V. G. Right paraduodenal hernia. *Surg. Clin. North America*, 1929, 9, 1015-1016.
- DOWDLE, E. Right paraduodenal hernia. *Surg., Gynec. & Obst.*, 1932, 54, 246-250.
- EXNER, F. B. Roentgen diagnosis of right paraduodenal hernia. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1933, 29, 585-599.
- FLECHTENMACHER, C. Hernia retroperitonealis mesenterica mit Einklemmung des gesamten Dünndarmes, Resektion des Bruchsackes, Heilung. *Zentralbl. f. Chir.*, 1929, 56, 1284-1286.
- GARDNER, C. E., JR., and HART, D. Anomalies of intestinal rotation as a cause of intestinal obstruction. *Arch. Surg.*, 1934, 29, 942-981.
- HALLIWELL, A. C. Right paraduodenal hernia. *Brit. J. Surg.*, 1934, 21, 398-403.
- HODGES, G. C. Case of right paraduodenal hernia; sixteenth recorded case of recovery after operation. *Roy. Melbourne Hosp. Clin. Rep.*, 1941, 12, 35-38.
- KLOB, Hernia retroperitonealis. *Wchnschr. d. Aertz in Wien*, 1861, V. 24.
- LAHEY, F. H., and TREVOR, W. Right paraduodenal hernia. *Ann. Surg.*, 1945, 122, 436-443.
- LOWER, W. E., and HIGGINS, C. C. Retroperitoneal hernia. *Ann. Surg.*, 1925, 82, 576-583; also in, *Tr. Am. Surg. Ass.*, 1925, 43, 586.
- MASSON, J. C., and McINDOE, A. H. Right paraduodenal hernia and isolated hyperplastic tuberculous obstruction. *Surg., Gynec. & Obst.*, 1930, 50, 29-39.
- NEUMAN, A. Ein Fall von operativ geheilter Hernia retroperitonealis mesenterico-parietalis. *Deutsche Ztschr. f. Chir.*, 1898, 47, 476-491.
- NOVAK, E., and SUSSMAN, A. A. Right paraduodenal hernia. *J.A.M.A.*, 1924, 82, 1664-1667.
- TAYLOR, J. The x-ray diagnosis of right paraduodenal hernia. *Brit. J. Surg.*, 1930, 17, 639-640.
- TREITZ, Hernia retroperitonealis, ein Beitrag zur Geschichte innerer Hernien. Prague, 1857.

DUODENAL DIVERTICULA WITH ULCERATION*

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FOR two hundred years after Chomel^{1,5} made the first report of a duodenal diverticulum there were few reports of this condition, all on autopsy findings, and in 1911 less than one hundred cases were on record.¹³ In 1913 Case¹⁰ reported 4 cases of duodenal diverticula diagnosed by roentgen examination and in 1920 he reported 85 such cases. In 1942 Finney¹² reviewed more than one hundred articles on duodenal diverticula published in the preceding ten years.

The cause of duodenal diverticula has been discussed by many writers. The sacs or pouches developed secondary to ulcer are false diverticula and properly are not considered in this paper. Diverticula have been classed as congenital when the walls contain all the layers of the intestine, and as acquired when lacking all or part of the muscle layer. It seems probable that in some cases at least a congenital defect

or weakness in the muscle layer may allow the protrusion of a small pouch of mucosa, and with the enlargement of this pouch the muscle layer becomes thinned out or disappears.¹² It is significant that duodenal diverticula are found rarely in individuals under thirty years of age and that the incidence increases with age.²

Duodenal diverticula may be missed on roentgen examination and may not be found on surgical exploration;^{3,4} unless a special search is made a diverticulum may be overlooked at autopsy. There is a great variation in the frequency reported by various authors (Tables IA and IB) ranging from 3 per cent to 22 per cent on autopsies and from 1.2 per cent to 5.3 per cent on gastrointestinal roentgen examinations.

In the past five years I and my assistants have found only 18 cases of duodenal diverticulosis in 5,712 gastrointestinal roentgen examinations. This low incidence of about

TABLE IA*

PERCENTAGE-FREQUENCY OF DUODENAL DIVERTICULA FOUND AT AUTOPSIES
AND AT ROENTGENOLOGIC EXAMINATIONS

Author	Year	Number of Autopsies	Number of X-Ray Examinations	Duodena with Diverticula	Percentage
Schuppel	1880	45		7	15.5
Rosenthal	1908	100		3	3.0
Baldwin	1911	105		14	13.3
Linsmayer	1914	1,367		45	3.3
Horton and Mueller	1933	216		11	5.09
Grant	1935	133		15	11.3
Case	1920		6,847	85	1.2
Andrews	1921		2,200	26	3.18
Spriggs and Marxer	1926		1,000	38	3.8
Cryderman	1927		770	40	5.19
Lemmel	1934		3,324	50	1.5
Rankin and Martin	1934		72,715	111	0.016
Edwards	1939		11,362	85	0.75

* From Ackermann.¹

* The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

TABLE IB
FREQUENCY OF DUODENAL DIVERTICULA

Author	Year	Number of Autopsies	Number of X-Ray Examinations	Duodena with Diverticula	Percentage
Gibbon ¹³	1933		1,978	20	1.05
Edwards ¹¹	1935		3,931	31	0.78
Lawson ²²	1935		2,250	36	1.6
Beals ²	1937		1,887	41	2.2
Browne and McHardy ⁵	1943		789	42	5.3
Ackermann ¹	1943	50		11	22.0

0.32 per cent may be due in part to the inexperience of some of the examiners, but more probably the main factor is the low average age, as most of our patients were in active naval service and a very high percentage of these were below thirty years of age.

Duodenal diverticula are rare in infancy²² and youth, not common in the middle decades, but found in a considerable percentage of individuals in the upper age groups; the average age in reported series of cases has been over fifty years (Table II). Our 18 cases ranged from seventeen to sixty-nine years of age, with an average of 38.5 years.

Very few true diverticula have been found in the first part of the duodenum; about 65 per cent of all reported cases have been in the second part, and about 30 per cent in the third and fourth parts (Table III). In 18 cases we found ten diver-

ticula in the second part, six in the third part and two in the fourth part.

When duodenal diverticula are not pressing on other organs or causing obstruction to the biliary tract they may produce no symptoms. In some cases there are complaints of vague upper abdominal pain, occasionally cramps, nausea or other digestive tract disturbances for which no cause, other than the diverticulum, may be found. If, after careful and repeated search for other pathology, no other cause is found, the diverticulum must be considered as producing symptoms. Conversely if no cause for gastrointestinal symptoms is found on routine examinations, a careful search for a diverticulum should be made. When there are complications the symptoms are more pronounced and severe. If a diverticulum is found and there is

TABLE III
LOCATION OF DUODENAL DIVERTICULA

TABLE II AGE DISTRIBUTION OF DUODENAL DIVERTICULA		
Author	Number of Cases	Average Age
Beals ²	34	53.3 years
Browne and McHardy ⁵	42	55% over 50
Case ¹⁰	85	56
Edwards ¹¹	31	51.9
Finney ¹²	19	63.7
Gibbon ¹³	20	52
Lawson ²²	36	51.4
Weintraub and Tuggle ¹⁷	310	60.3% over 50

Author	1st Part	2nd Part	3rd and 4th Parts
Ackermann ¹	0	6	8
Beals ²	0	28	17
Browne and McHardy ⁵	3	29	13
Case ¹⁰	17	49	19
Edwards ¹¹	0	22	9
Gibbon ¹³	1	12	8
Lawson ²²	8	16	12
Weintraub and Tuggle ¹⁷	6	248	95
Totals	35	410	181
Per cent	5.6	65.4	29

localized tenderness, the probability of diverticulitis or ulcer must be considered. When there is hemorrhage from the upper part of the gastrointestinal tract and a diverticulum is found, with no other cause for the bleeding, ulceration in the diverticulum is a reasonable conclusion.

Diverticulitis and ulceration in duodenal diverticula have been the subject of few reports, but it seems probable that some of the cases of duodenal diverticulosis with

had 4 cases of perivaterine diverticula, 1 causing obstruction of the bile duct and 3 associated with acute pancreatitis. Chomel⁵ reported a calculus in a duodenal diverticulum, and Rankin³⁴ a 2 inch gallstone in a duodenal diverticulum. Neoplasms in duodenal diverticula are very rare; Mendillo and Koufman²⁶ report a diverticulum with sarcoma of the duodenum; Morrison and Feldman³⁰ report 1 case of primary carcinoma in a duodenal diverticulum; Hod-

TABLE IV
DUODENAL DIVERTICULA WITH COMPLICATIONS

Author	Cases Reported	Number with Diverticulitis	Number with Ulcer	Number with Perforation	Number with Hemorrhage
Beaver ³	1			1	
Boland ⁴	1			1	
Browne and McHardy ⁵	42	3			
Finney ¹²	12				2
Hahn ¹⁵				2	
Huddy ¹⁸	1	1			
Lahey ²¹			1		2
Lucinian ²³	1			1	
Monsarrat ²⁷	1			1	

persistent symptoms may have ulceration in the diverticula. Browne and McHardy⁵ had 3 cases of diverticulitis in 42 cases of diverticulosis of the duodenum. Finney¹³ had 19 cases with duodenal diverticula in 2 of which there was hemorrhage for which no other cause could be found. Lahey²¹ had 2 cases of hemorrhage from duodenal diverticula; in one the bleeding spot was found in the excised diverticulum, and the pathological report was atypical gastric mucosa. Huddy¹⁸ reported a case of duodenal diverticulitis with gangrene; I have found six reports of perforated duodenal diverticula (Table IV) and there are probably other cases not reported or overlooked in my review of the literature. In our 18 cases there were 2 with severe and repeated hemorrhage; hemorrhage as well as perforation must be considered as due to ulceration.

Complications other than ulcer and inflammation have been reported; Ogilvie³²

ges¹⁷ describes a case of adenocarcinoma arising from the mucosa of a duodenal diverticulum which was buried in the head of the pancreas. I had 1 case similar to that of Hodges,⁷ a diverticulum of the second part of the duodenum extending into the pancreas; carcinoma was suggested on account of the irregular contour of the diverticulum, and this was confirmed at autopsy. Unfortunately the films and records were left in the Naval Hospital, Canacao, P. I.

The question of treatment of duodenal diverticula is one that must be decided for the individual patient. When the symptoms are not too severe and do not indicate the need for immediate surgery, diet and anti-spasmodics, or a modified ulcer regimen, should be continued for a long time and all other possible causes of the symptoms considered before surgery is advised. The operation for duodenal diverticulum is not a minor procedure and most of these pa-



FIG. 1. Case 1. Oblique projection showing diverticulum of fourth part of duodenum.

tients are not good surgical risks; the mere presence of a diverticulum is not an indication for surgery.¹² A careful clinical evaluation of the severity of the symptoms, the age and condition of the patient and the surgical procedures required must be made before surgery is advised. When there is biliary or intestinal obstruction, or perforation, the diagnosis of diverticulum is usually not made before operation. When there are severe and persistent symptoms not relieved by prolonged medical treatment, or when there is repeated hemorrhage, operation should be advised unless contraindicated by the condition of the patient.

Two of our cases had a history of repeated hemorrhage; surgery was advised and one case submitted to operation.

CASE REPORTS

CASE 1. I. F. W., white male, aged forty-nine; admitted January 16, 1941, complaining of

extreme weakness, nausea and dizziness. Previously the patient had not been seriously ill except for appendicitis in 1920, and after the appendectomy he continued in good health. For several years he had noticed that his abdomen seemed to swell after meals, and that he was uncomfortable after a large meal; he belched considerably and had noticed some shortness of breath. On January 12, after a few drinks, the patient felt nauseated and vomited; he returned to his ship and there vomited several times, the vomitus containing fresh blood and blood clots. The following day he noticed that his stools were black and tarry; stools have continued tarry since then. The night of January 15, while the patient was in a movie show he became nauseated and dizzy; he went to a nearby hotel and went to bed, said that he felt too weak to move for some time, but later telephoned for an ambulance; he was admitted after midnight. There was rather marked pallor, a pulse rate of 100, and slight tenderness over the left upper abdomen; physical examination otherwise was essentially negative. He was found to be slightly anemic; the stools were tarry during the first week in the hospital, and occult blood tests were positive for three weeks; routine laboratory studies otherwise were within normal limits. The patient was kept in bed on



FIG. 2. Case 1. Six hour residue in diverticulum.

Sippy regimen for ten days; there was no recurrence of vomiting or gross bleeding.

On January 29, 1941, gastrointestinal roentgen examination showed the esophagus, stomach, and upper duodenum to be normal. There was a diverticulum about 5 cm. in diameter extending from the anterolateral border of the fourth part of the duodenum just proximal to the duodenojejunal flexure. There was some irregularity in filling of the diverticulum (Fig. 1) possibly due to blood clot. Two small jejunal diverticula were noted and also a ring-shaped calcium deposit near the left kidney (aneurysm of the renal artery?). At six hours there was a barium residue in the diverticulum with a streaky density.

The patient did not desire operation and was returned to duty. He was re-examined in February and again in December, 1941; the diverticulum then filled with even density. No cause for bleeding other than the diverticulum was found. There had been no recurrence of bleeding at the time of the last examination, but the patient still complained of shortness of breath and a feeling of over-distention after meals.

CASE II. W. B. T., white male, aged thirty-three, was referred for gastrointestinal roentgen examination on June 5, 1944. He stated that he had had stomach trouble "all of his life," characterized by attacks of acute abdominal pain, cramps and nausea, frequently with vomiting. Vomiting usually relieved the acute attacks which occurred at intervals of from a few days to several months; the patient never felt entirely well between attacks but always had a feeling of abdominal discomfort and sometimes had "heartburn." Soda gave some relief but milk and other foods had little effect. The patient avoided large meals and fried foods as he had been advised to do so. He had consulted many physicians and had been given various treatments. In 1929 he had been operated on for acute appendicitis; this did not change the character of his symptoms. In 1936, twenty-four hours after a large dose of magnesium sulphate, given to stimulate gallbladder drainage, the patient had a severe hemorrhage; he vomited bright blood and passed changed blood per rectum. Since 1936 he has had several small hemorrhages, one of which followed passage of a duodenal tube. He has had six roentgen examinations of the gastrointestinal tract and gallbladder. One observer reported chronic



FIG. 3. Case II. Diverticulum of third part of duodenum.

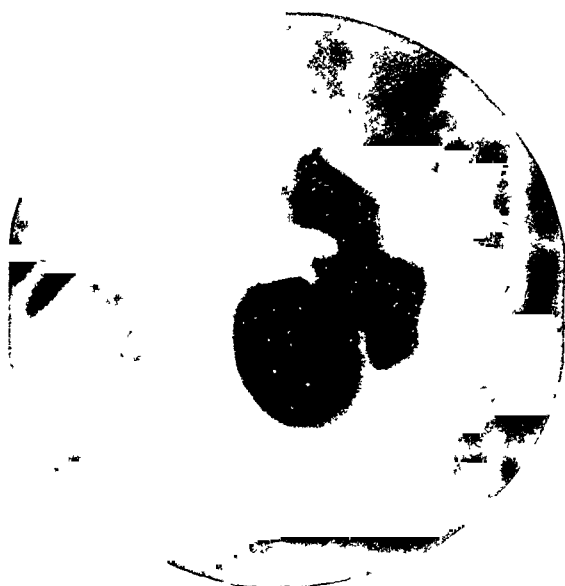


FIG. 4. Case II. Pressure spot film showing detail of diverticulum. Note appearance of niche.

cholecystitis, the other reports were negative. A competent surgeon refused to operate on the grounds that the history and symptoms were not those of gallbladder disease.

Gastrointestinal roentgen examination showed no abnormalities in the esophagus, stomach or upper duodenum. There was a diverticulum, about 3.5 by 2 cm., extending below the inferior margin of the duodenum at



FIG. 5. Case II. Excised diverticulum.

about the junction of the third and fourth parts, apparently arising near the mesentery. There was a narrow neck to the diverticulum and just below the neck on the right side there was a small niche (Fig. 4) and there was a contracture of the inferior wall so that the sac appeared to be lobulated. There was definite localized tenderness on pressure over the diverticulum. A report was made of a duodenal diverticulum with a niche indicating ulcer.

On June 12, 1944, patient admitted to hospital. Physical examination was essentially negative except for slight epigastric tenderness; all routine laboratory tests were within normal limits. The patient appeared depressed, and apprehensive; he was willing to submit to operation but seemed doubtful of being benefited; his general attitude was that of a neurotic individual.

On June 15 cholecystography showed a normally functioning gallbladder without calculi.

On June 19, operation by Commander J. D. Pessagno (M.C.) U.S.N.R.: "Upper right rectus incision, the fossa of Treitz was exposed and the ligament divided. About 8 cm. proximal to the duodenojejunal junction a diverticulum was found on the posterolateral surface of the inferior border of the duodenum. It was firmly adherent to the surrounding tissue and was freed by blunt dissection. Because of the narrow neck the diverticulum was excised without difficulty, and the duodenum was closed with two rows of silk sutures. The abdomen was closed in the usual manner."

The postoperative course was not unusual; fluids were given by mouth on the second day, soft diet started on the sixth postoperative day and full regular diet on the fourteenth day.

Pathological report, by Lieutenant Commander H. C. Allen (M.C.) U.S.N.R.: "Specimen is a diverticulum of the intestinal tract about 2 by 1.5 by 1.0 cm.; attached to the outside is a very small lymph node; in the central part of the diverticulum is an area where the epithelium is missing, covered with a blood clot (operative trauma?). Microscopic examination shows that the wall is made up of two distinct layers of muscle which are thin in some areas. The epithelium is papillary in type and the cells are tall and columnar with nuclei at the base; numerous cells contain secretory droplets; no Brunner's glands are present. The epithelium is a little thinned out in one area, but there are no fibrosis and no definite ulceration. There is a considerable number of lymphocytes and eosinophils at the base of the epithelium and some scattered among the muscle fibers. Diagnosis: congenital diverticulum of the small intestine."

The diverticulum, at operation, was clamped across the neck, and the small niche (Fig. 4) may have been crushed by the clamp or included in the line of excision. This niche could not be identified in the gross specimen; the contracture on the inferior wall was due to a band of adhesions.

July 24, re-examination of the gastrointestinal tract showed slight initial pylorospasm; there was very slight narrowing of the duodenum at the site of operation; there was normal progress of the meal at three and six hours. The patient felt much improved, but still had some abdominal discomfort; he said that he had had stomach ache so long that he "couldn't get his stomach off his mind." After the usual

convalescent leave, the patient returned to duty.

March 17, 1945, patient returned for check up; since operation he had had no acute abdominal pain, he has gained weight and feels well. He has had periods of abdominal discomfort, but this has only occurred when he was tired or worried. Roentgen examination of the gastrointestinal tract showed no evidence of pathology.

October 17, 1945, patient reports that he feels entirely well, with no recurrence of symptoms.

SUMMARY

Duodenal diverticula occur in certain individuals and are probably congenital or due to congenital defects in the intestinal wall; the incidence increases with age in reported series of examinations. Most duodenal diverticula cause no symptoms or only vague discomfort, but in some cases there are severe symptoms due to pressure on other organs or to complications. Ulceration may occur in the diverticulum, which may or may not contain atypical gastric mucosa; hemorrhage from a diverticulum is most probably due to ulceration. Pain and localized tenderness may be due to ulcer or diverticulitis.

In our 18 cases 16 had no symptoms that were considered as due to the diverticulum. One case had a gross hemorrhage repeated within a few days. One case had symptoms from childhood, and repeated hemorrhages over a period of eight years; excision of the diverticulum relieved the symptoms and there has been no recurrence in eighteen months.

ADDENDUM

I have reviewed a series of 645 gastrointestinal examinations made since my return to civilian practice; these cases were in an older age group than those covered by this paper, ranging from infancy to ninety-two years of age. There were 25 cases (3.88 per cent) with duodenal diverticulosis, with an average age of 55.8 years; the youngest was twenty-nine, and the oldest eighty-two. Five of these cases had definite symptoms for which no cause other than the diverticulum was found; one of these cases had a history of bleeding.

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REFERENCES

1. ACKERMANN, W. Diverticula and variations of the duodenum. *Ann. Surg.*, 1943, 117, 403-413.
2. BEALS, J. A. Duodenal diverticula. *South. M. J.*, 1937, 30, 218-222.
3. BEAVER, J. L. Acute perforation of duodenal diverticulum. *Ann. Surg.*, 1938, 108, 153-154.
4. BOLAND, F. K., JR. Acute perforated duodenal diverticulum. *Surgery*, 1939, 6, 65-67.
5. BROWNE, D. C., and McHARDY, G. Duodenal diverticulitis, acute and chronic. *New Orleans M. & S. J.*, 1943, 95, 553-558.
6. BUCKSTEIN, J. Duodenogram applied to demonstration of duodenojejunal diverticulum. *Am. J. Surg.*, 1927, 3, 340-341.
7. BUCKSTEIN, J. Clinical Roentgenology of the Alimentary Tract. W. B. Saunders Co., Philadelphia, 1940, p. 296.
8. BUCKSTEIN, J. Personal communication.
9. CASE, J. T. Roentgen observations on the duodenum with special reference to lesions beyond the first portion. *AM. J. ROENTGENOL.*, 1916, 3, 314-326.
10. CASE, J. T. Diverticula of small intestine, other than Meckel's diverticulum. *J.A.M.A.*, 1920, 75, 1463-1469.
11. EDWARDS, H. C. Diverticula of duodenum. *Surg., Gynec. & Obst.*, 1935, 60, 946-965.
12. FINNEY, J. M. T., JR. Duodenal diverticula; their significance and treatment. *South. Surgeon*, 1942, 11, 543-554.
13. GIBBON, W. H. Diverticula of duodenum. *Radiology*, 1933, 21, 491-494.
14. GUTHRIE, D., and BROWN, M. J. Diverticula of proximal intestine: duodenum and jejunum. *Am. J. Surg.*, 1938, 40, 128-139.
15. HAHN, O. Das Duodenaldivertikel. *Ergebn. d. Chir. u. Orthop.*, 1930, 23, 351-405. Quoted by Boland.⁴
16. HATCHETTE, S. Multiple diverticula of jejunum, duodenum and colon. *Radiology*, 1940, 34, 577-580.
17. HODGES, F. J. Gastrointestinal Tract. Year Book Publishers, Inc., Chicago, 1944, pp. 82-83.
18. HUDDY, G. P. B. Duodenal diverticula with report of a case of gangrenous diverticulitis. *Lancet*, 1923, 2, 327. Quoted by Beaver.³
19. KELLOGG, E. L. The Duodenum. Paul B. Hoeber, Inc., New York, 1933, pp. 221-239.
20. LAHEY, F. H. Surgery of duodenum. *New England J. Med.*, 1940, 222, 444-451.
21. LAHEY, F. H. Personal communication.
22. LAWSON, J. D. Duodenal diverticulosis. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1935, 34, 610-616.
23. LUCINIAN, J. H. Diverticulum of duodenum perforated into the pancreas. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1930, 24, 684-685.

24. LUST, F. J. Multiple diverticula of first part of duodenum. *Radiology*, 1937, 28, 620-621.
25. MACLEAN, M. J. Diverticulum of duodenum. *Surg., Gynec. & Obst.*, 1923, 37, 6-13.
26. MENDILLO, A. J., and KOUFMAN, W. B. Diverticulum and sarcoma of the duodenum. *New England J. Med.*, 1938, 219, 432-433.
27. MONSARRAT, K. W. Acute perforation of duodenal diverticulum. *Brit. J. Surg.*, 1926-1927, 14, 179-180.
28. MOORE, E. C. Lewis, Practice of Surgery. W. F. Prior Co. Hagerstown, Md., 1944, Vol. VI, Chap. 13.
29. MORRISON, T. H., and FELDMAN, M. Carcinoma in duodenal diverticulum with consideration of duodenal diverticulosis. *Ann. Clin. Med.*, 1925, 4, 403-414.
30. MORRISON, T. H., and FELDMAN, M. Autopsy report of a case of primary carcinoma in a duodenal diverticulum. *Ann. Clin. Med.* 1926, 5, 326-329.
31. MORTON, J. J. Surgical treatment of primary duodenal diverticula. *Surgery*, 1940, 8, 265-274.
32. OGILVIE, R. F. Duodenal diverticula and their complications with particular reference to acute pancreatic necrosis. *Brit. J. Surg.*, 1941, 28, 362-379.
33. PENDERGRASS, R. C. Duodenal diverticula, with report of two cases. *Am. J. Surg.*, 1928, 5, 491-497.
34. RANKIN, L. M. Diverticula of duodenum. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 585-587.
35. TANNER, W. E., and BENIANS, T. H. C. Congenital duodenal diverticulum. *Lancet*, 1939, 2, 1117-1118.
36. THOREK, M. Duodenal diverticula with ulcer. *Illinois M. J.*, 1929, 55, 64-68.
37. WEINTRAUB, S., and TUGGLE, A. Duodenal diverticula. *Radiology*, 1941, 36, 297-301.



A PATHOGNOMONIC ROENTGEN SIGN OF RETROPERITONEAL ABSCESS*

REPORT OF TWO CASES OF RUPTURED APPENDIX WITH POSITIVE ROENTGEN FINDINGS

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IN RECENT months we have had two cases of retroperitoneal abscess caused by gas-producing organisms, giving the pathognomonic roentgen sign of multiple small radiolucent shadows representing interstitial emphysema in the retroperitoneal tissues. In both cases, the source of infection was a ruptured retroperitoneal appendix. In one case we failed to make the diagnosis at the time of the initial study, because the gas bubbles appeared to be within the confines of the bowel. The history and clinical findings are important in that they should suggest a careful search for this infrequent and perhaps obscure finding. We consider stereoscopic roentgenograms of the abdomen and single views with the patient rotated to be helpful in making apparent the extraperitoneal location of the gas.

It occurred to us that this rather typical roentgen finding had been described adequately and repeatedly in the literature but a careful survey reveals only one article by Weens² emphasizing the characteristic sign. For this reason a report on our two cases seems warranted. Neuhof and Arnheim¹ reported 65 cases of lumbar and iliac retroperitoneal abscess and diffuse phlegmon, 12 of which were caused by retroperitoneal rupture of the appendix. The series is thoroughly worked up and critically analyzed, but no mention is made of the above roentgen sign.

The obvious large collection of gas with or without a fluid level, indicative of an abscess, needs no comment, and the better known roentgen signs of (1) loss of the

psoas shadow, (2) scoliosis with convexity away from the side of disease, (3) elevation of the diaphragm with limited excursions and (4) obscuration of the extraperitoneal fat layer are unreliable and often indefinite findings.

The first case seen by us was diagnosed because stereoscopic roentgenograms revealed innumerable small gas shadows behind the distended ascending colon and above the hepatic flexure.

CASE 1. The patient, a white male, aged forty-three, was admitted to the hospital with a presumptive diagnosis of right ureteral calculus and urinary infection. He was complaining of continuous and severe abdominal pain of three days' duration; at first the pain was epigastric, then generalized, and finally localized in the right loin and right lower quadrant. He had been taking fluids and was passing gas without difficulty. The temperature was 103.4° F., the pulse 120 and the respiration 32. Examination revealed active peristalsis and the abdomen was soft except in the right upper quadrant and loin. Maximum tenderness was localized in the right loin where fullness was noted. There was a moderate leukocytosis and the urinalysis was negative. The initial roentgen examination of the abdomen (Fig. 1) made in the supine position revealed considerable distention of the entire large bowel with extraluminal radiolucent gas shadows behind the right side of the colon from the ilium to the inferior margin of the liver. The right psoas shadow was obliterated. The following day subsequent roentgenograms of the abdomen were obtained with the patient supine (Fig. 2) and erect. The extraluminal small gas shadows were more numerous and better defined and the erect films revealed two fluid levels where the small radiolucent

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FIG. 1. Case I. A group of small, radiolucent shadows is seen on the right side, at the level of the eleventh intercostal space. Stereoscopic roentgenograms localized the gas collections far posteriorly and showed many more much less obvious radiolucent shadows behind the gas-containing ascending colon and hepatic flexure. The right kidney and psoas shadows are absent.



FIG. 2. Case I. Roentgenogram taken twenty-four hours after Figure 1. An increase in the abnormal

zones were confluent. Roentgenoscopy revealed elevation of the right leaf of the diaphragm and limitation of its excursion.

A large retroperitoneal lumbar abscess was drained surgically two days after admission. The pus was thin, light gray and of colon odor. Culture showed many coliform bacilli and anaerobic non-hemolytic streptococci. The patient recovered, and returned three months later for an elective appendectomy.

CASE II. The patient, a well developed colored male, aged thirty-one, was ill with ab-



FIG. 3. Case II. This study of the unprepared abdomen shows gaseous distention of numerous loops of small bowel. The significance of many small gas shadows on the right side was not immediately appreciated, these shadows being interpreted as representing gas mixed with fecal material in the cecum and ascending colon.

dominal pain for seven days before admission. The pain was sudden in onset, at first umbilical, gradually shifting to the right lower quadrant. On the day of admission the patient took a laxative and thereafter developed severe pain and vomiting. The patient stated that his ap-

radiolucent shadows is evident, extending downward to a larger collection of gas, just within the iliac fossa. The right kidney and psoas shadows remain absent.

pendix had ruptured nineteen years previously and was removed at that time.

On admission he was intermittently irrational and appeared dehydrated. The abdomen was tense because of distention but not rigid. Tenderness was elicited on deep palpation, diffuse, but more marked in the right lower quadrant. The temperature was 99.4°F., the pulse 100 and respiration 30. There was a moderate leukocytosis.

The initial roentgen examination (Fig. 3) showed marked distention of many loops of small bowel, and a diagnosis of obstruction was made. These roentgenograms revealed innumerable small gas shadows in the right side of the abdomen, but the significance of this finding was not immediately appreciated.

Four hours after the first film examination the abdomen was opened and the diagnosis of small bowel obstruction verified. The surgeon found an adhesive mass in the region of the cecum and lower ileum which was presumed to be the result of the operation nineteen years previously, but the appendix was not identified. An apparent volvulus of the lower ileum appeared to be relieved by severing the adhesions and the abdomen was closed. The patient remained acutely ill for the next five days and the abdomen remained distended despite attempts at decompression by the introduction of a Miller-Abbott tube.

On the fifth day a second roentgen examination of the abdomen revealed residual small bowel obstruction (Fig. 4) and innumerable extraluminal small gas shadows in the right retroperitoneal region were now quite apparent. An unqualified diagnosis of tissue emphysema due to a retroperitoneal abscess was made.

With this evidence the patient was reoperated, and a large quantity of foul-smelling thick pus was evacuated from the retroperitoneal space. A ruptured appendix was found, freed from its retrocecal position, and removed. The patient died shortly after the second operation. Postmortem examination revealed a large retroperitoneal abscess extending throughout the right lumbar and iliac area from the right leaf of the diaphragm to the attachment of the psoas to the femur. The bulk of the abscess was bounded inferiorly by the crest of the ilium.



FIG. 4. Case II. Roentgenogram taken five days after Figure 3. Distention of the large and small bowel is again seen and there is now a definite increase in the number, size and extent of small gas shadows on the right side indicative of retroperitoneal abscess.

CONCLUSIONS

Multiple small radiolucent shadows in the retroperitoneal space indicate an abscess or phlegmon.

Recognition of these multiple small gas shadows is possible early in the disease and their true location is facilitated by stereoscopic posterior or oblique projections.

Included are reports of two cases.

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REFERENCES

1. NEUHOF, H., and ARNHEIM, E. E. Acute retroperitoneal abscess and phlegmon; study of 65 cases. *Ann. Surg.*, 1944, 119, 741-758.
2. WEENS, H. S. Gas formation in abdominal abscesses; roentgen study. *Radiology*, 1946, 47, 107-115.

LYMPHOSARCOMA OF THE HEAD AND NECK*

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LYMPHOSARCOMA is a malignant neoplasm (a cancer) of lymph nodes and lymphoid tissue in general; any organ or tissue of the body may be affected, if not primarily, at least secondarily. The tumor has a characteristic microscopic appearance.

A review of the records at Memorial Hospital indicates that during the seven year period from 1935 through 1941 fifty-four patients with lymphosarcoma were examined and treated on the Head and Neck Service. All cases on first examination at the Hospital presented evidence of lymphosarcoma limited to structures in the head and neck. Routine physical examination, including a roentgenogram of the chest, was otherwise negative for lymphoma elsewhere in the body. Of these 54 cases, 4 are considered indeterminate for statistical study; 3 patients, clinically free of disease, died of other causes in less than five years; one patient, clinically free of disease, was lost track of after fifteen months.

It is the purpose of this paper to analyze the management of and report the five year end-results in the remaining 50 cases.

ETIOLOGY AND GENERAL INCIDENCE

The etiology of lymphosarcoma is unknown and no significant causative agent was noted in this series. According to our records the generalized form of lymphosarcoma is four times as common as lymphosarcoma of the head and neck; 217 cases of generalized disease were treated during the same period as the 54 cases under consideration here.

The disease was found in 29 males and 21 females, the youngest patient being a ten year old boy, the oldest patient a woman,

aged eighty-eight. The age distribution of cases, according to decades, is shown in Table I. As would be expected in a form of cancer, the largest number of cases occurred during the fifth and sixth decades.

TABLE I
AGE INCIDENCE
(in decades)

	Cases
10 to 20 years	4
21 to 30 years	4
31 to 40 years	7
41 to 50 years	7
51 to 60 years	14
61 to 70 years	11
71 to 80 years	1
81 to 90 years	2
	—
Total	50

The distribution of cases, according to the anatomical location of the primary growth, is shown in Table II. It is interesting to note that 40 per cent of the entire series presented the primary focus in the tonsil (essentially a lymphoid structure).

TABLE II
ANATOMICAL DISTRIBUTION OF THE
PRIMARY TUMOR

	Cases
Tonsil	20
Soft parts of head and neck including nodes	11
Nasal cavity	5
Nasopharynx	4
Antrum (paranasal sinuses)	3
Palate	2
Orbit	2
Tongue	1
Gingiva	1
Pharynx	1
	—
Total	50

The next largest group was found in those cases with the disease first appearing in the soft parts (including lymph nodes) of the head and neck region.

* From the Head and Neck Service of Dr. Hayes Martin, Memorial Hospital, New York, N.Y. Presented at the Twenty-ninth Annual Meeting, American Radium Society, Atlantic City, N. J., June 9-10, 1947.

PATHOLOGY

Our Pathology Department examined the diagnostic tissue in every case. Twenty-eight cases were classified as lymphosarcoma, reticulum cell type. Twenty-two cases were classified as lymphosarcoma.

DIAGNOSIS

The *clinical diagnosis* of a tumor was not difficult in most cases. Forty-six patients each presented a visible and palpable primary growth from which histopathologically positive tissue was obtained. Two cases were first diagnosed by excision of a palpable neck node, the primary focus in the nasopharynx being found and proved histopathologically at a later date.

One patient upon whom a tonsillectomy had been recently performed elsewhere showed no tumor clinically, and the diagnosis was established on the submitted operative specimen.

One case with lymphosarcoma of the orbit showed only unilateral exophthalmos, without palpable tumor; again the diagnosis was made on the submitted operative tissue from the orbit.

The *pathological diagnosis* was established in 21 cases by tissue biopsy from the primary tumor; 18 cases submitted positive biopsies taken before admission to our service. Seven cases required excisional biopsy of an accessible lymph node for microscopic study. In 4 cases surgical removal of the primary growth resulted in a positive diagnosis being made on the operative specimen.

TREATMENT

Previous Treatment. Treatment given previous to admission on our service consisted of biopsy only in 16 cases, some type of local surgery (excisional biopsy, incision and drainage, etc.) in 7 cases, local applications or mouth washes in 4 cases, tonsillectomy in 3 cases and tooth extractions in 3 cases. In addition 2 patients received small amounts of radiation as well in the form of roentgen rays or radium. One nasal

cavity case was subjected to a resection of the nasal septum and a tonsillectomy before a biopsy from the right nasal cavity revealed the true nature of the disease. Sixteen cases were referred directly to us without treatment of any kind.

Certain principles are adhered to in this clinic when using radiation in the treatment of *carcinoma* of the head and neck. External roentgen therapy is administered with the high voltage machine (200-250 kv. at 35 or 50 cm. target skin distance). Low voltage roentgen therapy (100 kv.) at 20 cm. target skin distance is frequently employed for peroral therapy. Circular, oval, or specially shaped portals just large enough to adequately cover the disease are used and a relatively large total dose given by the fractionated dose method. Roentgen treatment is supplemented with one or more doses of interstitial radiation in the form of gold filtered radon seeds.

The above principles, with slight modification, are also employed in the treatment of *lymphosarcoma*. In general, the total dose of roentgen radiation is not as high and radon seeds are not used as frequently. For example, in the series under consideration, only 7 patients received interstitial radiation as part of the initial treatment.

Initial Treatment (to the primary tumor and any co-existing regional metastases). In our experience roentgen therapy has been the treatment of choice and was used in 49 of the 50 cases. The amount of treatment given depended on the size, location, and amount of disease, the number of portals employed, and the judgment of the clinician. Treatment time varied from three to ten weeks. Every case was individualized and treated in accordance with its own particular requirements. The following examples demonstrate in a general way the method of treatment. Roentgen-ray dosage is expressed in roentgens measured in air.

CASE I. E. M., aged sixty-five. Diagnosis: lymphosarcoma right tonsil with metastases to right upper neck nodes. Treatment: 250 kv., 50 cm. target skin distance, 9 by 6 cm. oval right mandibular and upper neck portal; total

dose 4,200 r; 8 cm. circular left mandibular portal; total dose 4,200 r. Treatment time four weeks. This patient has been free of disease for seven years.

CASE II. J. B., aged fifty-one. Diagnosis: lymphosarcoma left cervical lymph nodes. Treatment: 250 kv., 50 cm. target skin distance, 15 by 10 cm. rectangular left neck portal; total dose 4,800 r supplemented with three doses of radon seeds for a total of 23 mc. Treatment time four weeks. This patient died of generalized disease five months later without local recurrence in the neck.

CASE III. J. S., aged twenty. Diagnosis: lymphosarcoma of right parotid area with metastases to right upper cervical lymph nodes. Treatment: 250 kv., 50 cm. target skin distance, 9 by 6 cm. oval right mandibular and upper neck portal; total dose 4,250 r. Treatment time three weeks. This patient has been free of disease for five and one-half years.

CASE IV. I. R., aged thirty. Diagnosis: lymphosarcoma of the hard palate. Treatment: 200 kv., 50 cm. target skin distance, 4 cm. bilateral circular right and left maxillary portals; total dose 1,500 r \times 2; also 200 kv., 20 cm. target skin distance, 5 cm. circular peroral field; total dose 3,000 r. Treatment time three weeks. Patient has been free of disease for nine years.

Six cases received less intensive treatment. Three of these patients discontinued treatment before its completion and all are dead of generalized disease, 1 in four months, 1 in seven months, and 1 in twenty months respectively. The remaining 3 patients received mild treatment because it seemed clinically sufficient in these cases. Although all 3 patients have survived five years or more, we do not feel that this less intensive therapy is to be recommended as a routine.

Surgery was used as the initial treatment in only 4 cases. In these cases surgery was elected to establish the diagnosis and remove a bulky mass of disease. Two of these 4 patients received postoperative roentgen treatment to the operative area. One patient received no further treatment and died in another hospital two months later, supposedly of "sarcoma"; although this

case is considered a failure, there is good circumstantial evidence to indicate that death was cardiac in nature and not due to recurrent lymphosarcoma. The fourth patient subsequently received roentgen treatment and further surgery and at present is clinically free of disease.

Treatment of Recurrent Disease and Subsequent Metastases. Twenty-five cases (50 per cent) required additional treatment, either to recurrent disease locally or to the development of new metastases.

The incidence of local recurrence in previously treated areas was infrequent and occurred in only 9 cases (18 per cent).

In 20 cases (40 per cent) the disease eventually progressed beyond the head and neck region and became generalized.

All 25 patients developing further disease were treated with high voltage roentgen rays. Interstitial radon seeds were used as well in 3 cases. One patient was treated with a radon capsule (1,000 mc-hr.) placed in the nasopharynx for a primary growth which became apparent fifteen months after initial treatment to a right neck mass; this patient died five years later of coronary occlusion and without further evidence of lymphosarcoma.

Surgery was used for recurrent disease in 1 patient only. This remarkable case was treated by partial right neck dissection for recurrent disease in the right upper neck which persisted despite the use of heavy roentgen therapy. The initial treatment given twenty-two months previously consisted of a left radical neck dissection for a bulky mass of disease in the left neck. The patient is now clinically free of disease six and one-half years later.

Complications of Treatment.

Immediate Complications: Most of these patients developed the usual skin reaction and mucositis associated with radiation therapy. These reactions caused no particular problem when given routine hygienic and supportive care. The weight and general condition of each patient was maintained as well as possible during the treatment period with a high caloric, high vita-

min diet. One patient required tracheostomy for acute laryngeal edema. Another patient with bulky disease in both tonsils died of asphyxia before a tracheostomy was done.

Late Complications: Three patients developed marked radiation atrophy with crusting of the nasal and pharyngeal mucosa; undoubtedly, more patients suffered from this complication than the records indicate. One patient required enucleation of the right eye for radiation necrosis of the cornea.

PROGNOSIS

It is a generally accepted principle when dealing with lymphosarcoma to record "five year survivals" rather than "five year cures." The chronicity and unpredictable course of the disease make this classification necessary.

In this series, 23 patients (46 per cent) presented only the primary tumor on initial examination; 14 (per 61 cent) have survived five years or more. Only 5 developed cervical lymph node metastases later, and 3 of these have survived five years or longer.

Twenty-seven patients (54 per cent) presented one or more enlarged cervical nodes in addition to the primary mass when first examined; 12 (44 per cent) have survived five years or more.

In 20 cases (40 per cent) the lymphosarcoma became generalized and in this group there is only one five year survival (5 per cent).

It can thus be seen that the prognosis is most profoundly affected by whether the disease becomes *generalized* or not. In a careful analysis of this series of 50 cases it has been impossible to uncover any single factor or factors which will indicate the subsequent course of the disease. Whether an individual case will go on to generalized dissemination of the lymphosarcoma or not seems to depend on an unknown characteristic of the disease. It is highly probable that some patients already have unrecog-

nized generalized disease when first examined and when positive findings are clinically still localized in the head and neck region.

Clinical observation has shown that a patient may present either a single focus of disease or multiple and widespread foci; both unicentric and multicentric forms of lymphosarcoma are constantly encountered. To us as clinicians, it seems reasonable and practical to consider the disease localized and unicentric in origin when initial positive findings are limited to the head and neck. It is this attitude which has prompted us to treat most of these cases *intensively* in an attempt to sterilize the disease while it may still be localized.

END RESULTS

Table III shows that 26 of the 50 patients (52 per cent) have survived five years or longer. Of these 26 patients, 24 are clini-

TABLE III
FIVE YEAR END RESULTS
(IN TERMS OF SURVIVAL)

Total Number of Patients.....	54
Indeterminate group	
Dead of other causes without evidence of disease.....	3
Lost track of without disease.....	1
Total.....	4
Determinate group	
Total number minus indeterminate group..	50
Failures	
Dead of disease.....	24
Successful results	
Patients having survived five years or longer.....	26
Five year end results	
Total successful results divided by total determinate group (26/50).....	52%

cally free of disease and apparently cured; 2 are living with further evidence of disease.

Craver has recently reported an over-all five year survival rate of 26 per cent in a series of 308 patients with lymphosarcoma

of all anatomical types treated at the Memorial Hospital during the eleven year period from 1930 through 1940; it is noteworthy that of the 81 survivors, 40 are patients in whom the disease was at first found only in the head and neck region.

In a group of 119 patients treated at the Presbyterian Hospital, Stout reports a five year survival of 23 per cent and a ten year survival of 13 per cent. He indicates that five year survivals are higher in oral cavity and salivary gland patients (37 per cent) than in patients with generalized disease (10 per cent).

It is realized that this analysis is limited to 50 cases and that the high five year survival figure of 52 per cent might be lower in a larger series. However, it seems an indisputable fact that lymphosarcoma of the head and neck carries a relatively favorable prognosis as compared to the generalized form of the disease. The realization of this fact should influence the optimism and aggressiveness with which this anatomical form of the disease is treated.

SUMMARY AND CONCLUSIONS

1. Fifty cases of lymphosarcoma clini-

cally localized in structures of the head and neck are presented for analysis.

2. The etiology of the disease is not known. The distribution between the sexes was about equal. The disease was most prevalent during the fifth and sixth decades.

3. The diagnosis was confirmed in all cases by tissue biopsy.

4. The treatment of choice was high voltage roentgen therapy supplemented with interstitial gold radon seeds in some cases. Surgery was of value in only four cases to establish the diagnosis and remove a bulky deposit of disease.

5. The prognosis in lymphosarcoma of the head and neck is more favorable than in the generalized form of the disease.

6. The five year survival rate in this series is 52 per cent.

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REFERENCES

1. CRAVER, L. F. *Bull. New York Acad. Med.*, 1947, 23, 79.
2. STOUT, A. P. *New York State J. Med.*, 1947, 47, 158.



PANTOPAQUE MYELOGRAPHY IN THE DIAGNOSIS OF THE ARNOLD-CHIARI MALFORMATION WITHOUT CONCOMITANT SKELETAL OR CENTRAL NERVOUS SYSTEM DEFECTS*

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THE Arnold-Chiari malformation of the hindbrain is a downward elongation of the cerebellum and brain stem through the foramen magnum into the cervical spinal canal. A congenital defect which may occur in varying degrees, it is often associated with spina bifida, myelomeningocele and hydrocephalus, but it may also occur in patients with neither skeletal nor central nervous system defects. It has also been reported in conjunction with bony abnormalities of the craniovertebral junction like platybasia and fusion defects of the cervical spine and the occipitocervical area.⁶ Its age incidence varies from the newborn infant to patients in adult life, and the diagnosis is usually made on the basis of clinical, and more frequently anatomical observations either at operation or autopsy.

The roentgen findings have not received intensive study, and pantopaque myelography offers an additional diagnostic procedure which is worthy of careful consideration. In April, 1941, List⁷ mentioned 2 patients who had had iodized oil myelography as a diagnostic procedure, in one of whom the diagnosis of an Arnold-Chiari malformation was made preoperatively. This patient also had a bony abnormality of the craniovertebral junction. In July, 1941, another and more detailed myelographic study of a patient with an Arnold-Chiari malformation without other abnormalities in the skull or spine was reported by Adams, Schatzki and Scoville.¹ The present communication is concerned with a fourth such patient examined with pantopaque myelography.

CASE REPORT

M. W. (Case No. 282825), female, aged thirty, complained of pain in her left shoulder radiating to the hand, with unusual sensitivity of the skin of her left arm to thermal stimuli. This started three months after the birth of her second child three years before admission to the hospital. Extreme paroxysms of pain could be precipitated by coughing or sneezing. She noted a "burning coldness" almost immediately on placing her hand in cold water, while ordinary exposure to room temperature elicited a lesser feeling of discomfort. Recently a tendency to fall frequently and a perceptible clumsiness in gait appeared. There was no noticeable muscle atrophy.

Physical examination disclosed a left Horner's syndrome. Slight diminution of sensation in the left arm with hypesthesia in the distribution of the fourth and fifth cervical dermatomes was present. The left abdominal skin reflex was less active than the right, and there was some question whether sensation in her left lower extremity was somewhat less than on the right side. The deep reflexes were diminished in the left upper extremity as compared with the right. There were no sphincteric disturbances, nor were there any muscular weaknesses.

Lumbar puncture revealed an initial pressure of 210 mm., which rose to 430 mm. of water with 40 mm. of mercury of jugular pressure applied with a blood pressure apparatus. The pressure fell to 210 mm. in ten seconds. The findings were considered indicative of a partial block. There were 39 cells per cc. of fluid. The total protein content was 35 mg. per 100 cc. The Wassermann and colloidal gold tests were negative.

Roentgenographic examination of the cervical spine revealed a straightening of the usual cervical curve. The vertebral bodies and interspaces were normal, and no changes were pres-

* From the Radiologic Service of M. G. Wasch, M.D., The Jewish Hospital of Brooklyn, Brooklyn, N.Y.

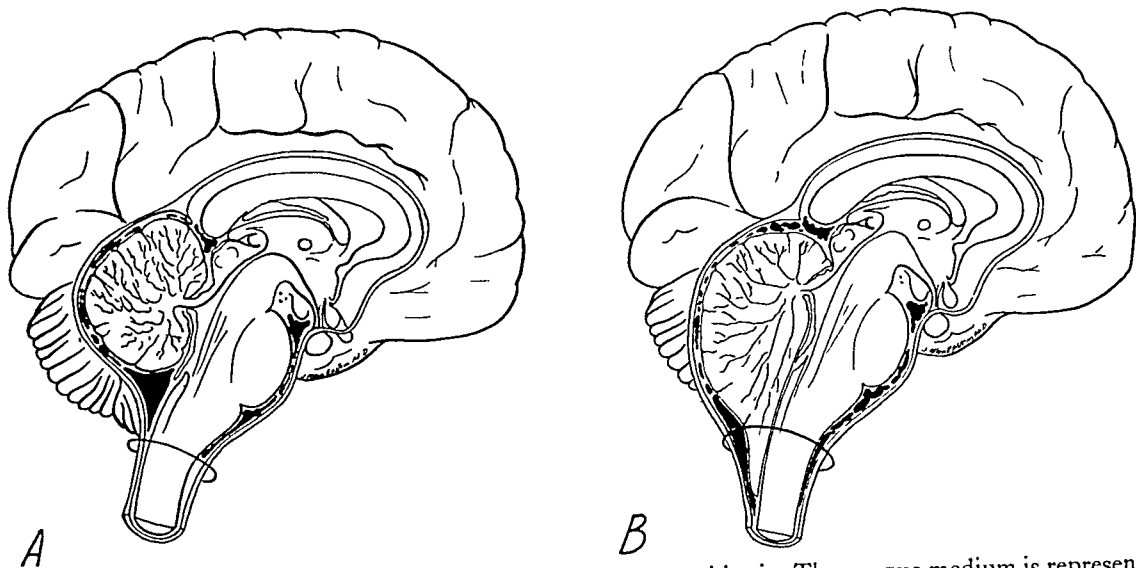


FIG. 1. *A*, diagrammatic drawing of a sagittal section of the normal brain. The opaque medium is represented in black. The downward impression of the cerebellum results in a concave appearance of the cephalad margin of the pool. *B*, diagrammatic representation of the Arnold-Chiari malformation is found in the patient reported here. The pantopaque is collected above and beneath the cerebellar tonsils because the herniated portion of the cerebellar tonsils partially fills and distorts the cisterna magna.



FIG. 2. *A*, normal myelogram of the cervico-occipital junction with the head turned towards the right. The impression of the lower cerebellum into the pool of pantopaque results in a triangular shadow with a slightly concave hypotenuse. *B*, myelogram of the cervico-occipital junction of the patient reported here. The pantopaque is shifted cephalad and caudad by the displaced cerebellar tonsils. The upper radiopaque shadow is caused by the pantopaque gathered above the cerebellar tonsils and the inferior curvilinear defect outlines the lowermost margins of the lesion.

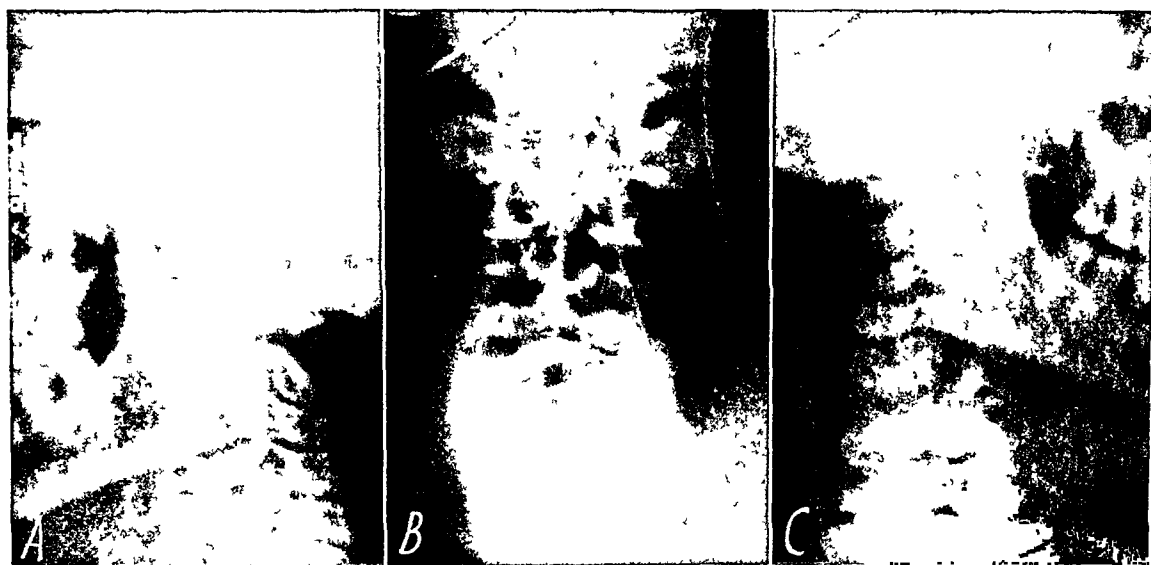


FIG. 3. *A*, the pantopaque is gathered in the upper cervical region. The patient's head is turned toward the right. The curvilinear impression into the cephalad margin of the pool is well portrayed. A small amount of the pantopaque has entered the cisterna pontis. *B*, direct anteroposterior view of the pantopaque gathered in the upper cervical region. A biconcave filling defect with a central isthmus of pantopaque is present. *C*, the same findings as noted in *A* can be seen with the patient's head turned toward the left.

ent in the occipitocervical region. Examination of the lumbosacral and lower thoracic spine likewise showed no skeletal defects.

Myelography was performed after the injection of 3 cc. of pantopaque between the third and fourth lumbar vertebrae. A persistent partial obstruction was encountered at the level of the interspace between the first and second cervical vertebrae. The head of the pantopaque column assumed a semicircular configuration concave caudally. With the patient's head turned toward the left and the right sides the filling defect in the oil column was unchanged. The findings were considered indicative of an intrinsic lesion, probably an extramedullary tumor.

At operation the posterior arches of the first, second and third cervical vertebrae were removed and the occipital foramen was enlarged posteriorly. The dura appeared to be under normal tension and no evidence of tumor was found on palpation. The membrane was opened in the midline for about 2.5 cm. and no gross pathologic changes were found beneath the meninges. After removing the posterior arch of the atlas a mass was seen invading the upper portion of the cervical canal. This was identified as cerebellum, was white in color and covered with a whitish fibrous tissue. The findings were considered indicative of the Arnold-Chiari malformation. No downward displacement of the brain stem could be observed.

NOTES ON THE ROENTGENOLOGIC FINDINGS

A review of the roentgenograms after operation brought out some interesting details. The direct examination of the cervical spine showed only a change in the normal curvature of the cervical spine. No derangement was present at the occipitocervical junction, and the lumbosacral spine was normal. The myelographic findings were most important. The persistence of the concave defect in the pantopaque column with the patient's head turned to the right and left sides could, on second thought, indicate the presence of a lesion to either side of the midline. A film taken with the patient's head in the direct anteroposterior projection was available. This showed the iodized oil column through the ethmoidal sinuses in the upper cervical canal and the cisternae magna, pontis and interpeduncularis. The bilateral nature of the filling defect was better visualized here. The two radiolucent indentations were separated by a column of oil about 8 mm. wide and 2.5 cm. long. This oil apparently rested in the cleft between the herniated cerebellar tonsils. The outlines of the concave filling defects were rather indistinct, although no gross changes which

might be interpreted as cerebellar gyri could be distinguished.

The configuration of the pantopaque in the cisterna magna as seen with the patient's head turned to the side was most interesting. A slight cephalad convexity of the pool of oil gathered in the cisterna magna was present in the patient with the Arnold-Chiari malformation, and the cisterna pontis seemed to be slightly narrowed. Reviewing a number of other cervical myelograms, it was noted that normally the oil pool in the cisterna magna is concave caudad and somewhat anteriorly, following the normal cerebellar contour. The change in curvature in the patient with the Arnold-Chiari malformation may be understood by referring to Figure 1, which was adapted from that in the excellent paper by Adams, Schatzki and Scoville. Under normal conditions the inferior aspect of the cerebellum is slightly bulged downward, dipping into the cisterna magna whereas with the Arnold-Chiari malformation as seen in the patient reported here the cerebellum slips downward and forward, thus distorting its contour by displacing and changing the appearance of the oil gathered in the cisternae magna and pontis.

The myelographic findings reported by List were an arrest in the passage of the iodized oil in the high cervical region with a filling defect characterized by a concave upper margin. Very little lipiodol entered the cisterna magna and a little more appeared in the cisterna pontis as seen on the line drawings published. The diagnosis of an Arnold-Chiari malformation was made preoperatively on one of his two patients.

Adams, Schatzki and Scoville describe the myelographic observations as portraying "a mass within the upper cervical area which produces a fairly marked block to lipiodol injected below the lesion. The block is less complete than one would expect from a tumor of similar size, the passage into the vault being less impaired than that in the reverse direction. The outline of the mass is less distinct than that of tumor, owing to the sloping surfaces of the soft cerebral tonsils. The edge of the

mass shows lobulation produced by the gyri of the prolapsed cerebellum. There seems to be a small central incisura within the mass corresponding to the incisura between the two cerebral tonsils. Some degree of platybasia may be present." There is no doubt that the reference to "cerebral tonsils" is a misprint, the correct terminology being "cerebellar tonsils."

To this adequate picture might be added the changes noted in the configuration of the iodized oil collected in the cisternae magna and pontis, but the latter changes will only occur when a sufficient quantity of oil enters the cisterns.

CLINICAL NOTES

In 1894 Arnold³ reported the case of a newborn infant with lumbosacral spina bifida and myelocoele who also had a protrusion of a portion of the cerebellum through the foramen magnum over the dorsal aspect of the upper cervical spinal cord containing the fourth ventricle. Soon thereafter Chiari⁵ classified 63 such cases and described three general types of the malformation. The first was characterized by elongation of the cerebellar tonsils and inferior lobes, enveloping the medulla and extending into the upper cervical canal without downward displacement of the fourth ventricle. This type occurred in adults as well as children and could be associated with internal hydrocephalus without myelomeningocele. The second type presented a more advanced deformity with displacement of the fourth ventricle caudad so that the foramina opened into the spinal subarachnoid space below the foramen magnum. This group occurred in infants with internal hydrocephalus and spina bifida. The third, most advanced and least common type presented a downward herniation of the whole hydrocephalic cerebellum into the cervical spinal canal.

The pathogenesis of the Arnold-Chiari malformation has not been decided with absolute certainty. Some believe that it is most likely a deformity resulting from a change in the relationship of the hindbrain to its bony envelope. Abnormal fixation of



FIG. 4. *A*, lateral roentgenogram of the neck showing straightening of the normal cervical curve. The cranio-cervical junction is normal. *B*, anteroposterior view of lumbosacral spine. No congenital defects are present.

the spinal cord to its meningeal coverings and roots by a spina bifida defect might prevent normal ascent of the spinal cord with the growth of the spinal column and the development of the cauda equina. The greater the defect and the more caudal its location, the earlier the appearance of the deformity and its concomitant complications.¹⁰ List⁷ mentions the fact that the Arnold malformation is a tereotopic displacement of cerebellar tissue into the spinal canal, while Chiari's deformity is a peculiar bulging or kinking of the posterior part of the medulla against the spinal cord. From the clinical viewpoint the two conditions are usually linked and considered as a single entity.

The Arnold-Chiari malformation has also been observed in conjunction with such bony abnormalities of the craniovertebral junction as platybasia and fusion abnormalities of the cervical spine and the occipitocervical area. This group is particularly well reported by List, whose paper deserves careful study.

It is worth reiterating that not all patients with the Arnold-Chiari malformation have associated hydrocephalus, meningocele, spina bifida or anomalies of the craniovertebral junction. Aring² reported an adult patient with cerebellar symptoms who had this condition without associated hydrocephalus or meningocele. McConnell and Parker⁸ reported 5 similar cases apparently unassociated with other skeletal or central nervous system defects, while Ogryzlo⁹ found no other abnormalities in 3 of his cases. Bucy and Lichtenstein⁴ reported a case in an adult patient where the malformation was large enough to produce marked neurologic symptoms with no evidence of spina bifida or other bony abnormality, and commented that this combination of circumstances was most unusual. The patient reported in this communication likewise had no other skeletal or central nervous defects, and the entire group was seen to correspond to that mentioned by Chiari in his first type.

The symptomatology presented by the

patients without concomitant skeletal defects may be quite variable. Bucy's patient had partial paralysis of both lower extremities and the right upper extremity which appeared suddenly about three months before hospitalization. There was deviation of the tongue towards the right, ataxia on the right but no signs of increased intracranial pressure. There was atrophy and fibrillar twitchings of the right side of the tongue, hypalgesia of the right side of the body with the exception of the face, nystagmus and bilateral foot drop. The Achilles tendon reflex disappeared later, and marked pitting edema of the feet and ankles then appeared. The abdominal reflexes were absent, and a three plus positive Hoffman's sign was elicited on the right. The tendon reflexes were reduced on the left side. Cerebrospinal fluid examination revealed a complete subarachnoid block and total protein content of 40 mg. per 100 cc.

Ogryzlo described the symptomatology in his patients as varied and inconstant. Cerebellar tumor was the most common preoperative diagnosis, and it was usually not until the surgical exposure was made that the true nature of the lesion was recognized. Early morning headache, cerebellar-type ataxia, nystagmus, palsy of the cranial nerves, visual disturbances, papilledema and vomiting were present in varying degrees. Pain in the suboccipital, occipital or high cervical regions due to compression of the upper nerve roots may occur. Paresthesias in the upper extremities may be prominent. Sometimes pain could be relieved by stretching or forward flexion of the neck, while coughing or sneezing might aggravate the pain.

To this bizarre symptomatology might be added the Horner's syndrome found in the patient reported here.

The findings on examination of the cerebrospinal fluid are helpful. A partial or complete subarachnoid block may be encountered on manometric study. Some elevation of the cerebrospinal fluid protein content may be present¹ but normal values have been reported as well.

SUMMARY

An adult female patient with an Arnold-Chiari malformation without skeletal or other central nervous system defects studied with pantopaque myelography is reported. The myelographic findings present a definite pattern whereby the diagnosis may be established preoperatively. It is suggested that this procedure might possibly find application in the investigation of children with hydrocephalus.

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REFERENCES

1. ADAMS, R. D., SCHATZKI, R., and SCOVILLE, W. B. Arnold-Chiari malformation; diagnosis, demonstration by intraspinal lipiodol and successful surgical treatment. *New England J. Med.*, 1941, 225, 125-131.
2. ARING, C. D. Cerebellar syndrome in adult with malformation of cerebellum and brain stem (Arnold-Chiari deformity), with note on occurrence of "torpedoes" in cerebellum. *J. Neurol. & Psychiat.*, 1938, 1, 100-109.
3. ARNOLD, J. Myelocyste, Transposition von Gewebskeimen und Sympodie. *Beitr. z. path. Anat. u. z. allg. Path.*, 1894, 16, 1. Quoted by Ogryzlo.⁹
4. BUCY, P. C., and LICHTENSTEIN, B. W. Arnold-Chiari deformity in an adult without obvious cause. *J. Neurosurg.*, 1945, 2, 245-250.
5. CHIARI, H. Ueber Veränderungen des Kleinhirns, des Pons und der Medulla Oblongata in folge von congenitaler Hydrocephalie des Grosshirns. *Denkschr. d. k. Akad. d. Wissensch. Math-naturw. Klasse*, 1895, 63, 71. Quoted by Ogryzlo.⁹
6. INGRAHAM, F. D., and SCOTT, H. W., JR. Spina bifida and cranium bifidum. V. The Arnold-Chiari malformation; study of 20 cases. *New England J. Med.*, 1943, 229, 108-114.
7. LIST, C. F. Neurologic syndromes accompanying developmental anomalies of the occipital bone, atlas and axis. *Arch. Neurol. & Psychiat.*, 1941, 45, 577-616.
8. MCCONNELL, A. A., and PARKER, H. L. Deformity of hind-brain associated with internal hydrocephalus. Its relation to Arnold-Chiari malformation. *Brain*, 1938, 61, 415-429.
9. OGRYZLO, M. A. The Arnold-Chiari malformation. *Arch. Neurol. & Psychiat.*, 1942, 48, 30-46.
10. PENFIELD, W., and COBURN, D. F. Arnold-Chiari malformation and its operative treatment. *Arch. Neurol. & Psychiat.*, 1938, 40, 328-336.

SPONTANEOUS RUPTURE OF THE KIDNEY

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TRAUMATIC rupture of the kidney is by no means a rare incident and may occur in primarily healthy kidneys as well as in diseased ones, but spontaneous rupture of the kidney occurs rarely and is invariably connected with chronic renal disease. The spontaneous rupture may involve the parenchyma or the renal pelvis or both, depending upon the anatomic localization of the pathologic process. A large variety of renal diseases may terminate in spontaneous rupture and impacted stones make up the majority of the cases reported in the literature, but pyelonephritis, pyonephrosis, tuberculosis and tumor have also been encountered as causative factors.

The exclusion of a minimal trauma to a diseased kidney is not always as easy as it may appear. Often the trauma may be so minimal that the patient has no suspicion or knowledge of any injury and therefore the history fails to reveal trauma. The literature on this subject reveals reports of traumatic rupture of diseased kidneys merely upon muscular effort, therefore strict differentiation between traumatic rupture of a diseased kidney and spontaneous one is not always possible.

In cases of stone impaction, the stone itself may represent the traumatic factor, particularly if ulceration and necrosis of the mucosa of the ureter or renal pelvis takes place. Several cases of rupture in hydronephrosis associated with obstruction of the ureter have been reported which include a case report by Jewett of ruptured hydronephrosis associated with carcinoma of the ureter and other similar cases by Mathe and Oviedo and by Dourmashkin. Spontaneous rupture in hydronephrosis and pyonephrosis without additional ureteral obstruction has been reported by Henline, Abeshouse, Crabtree, and others. The

reported case is of interest because an unusually large number of stones escaped through a perforation of the renal pelvis into the perinephric space and along the right psoas muscle downward into the pelvis. As mentioned above, all cases of spontaneous rupture of the kidney represent more or less severe degrees of chronic renal disease. The surgical treatment must necessarily consider this fact and therefore be distinctly separated from the surgical treatment of traumatic rupture of a primarily normal kidney. In the latter condition every attempt should be made to preserve the kidney provided the extent of injury warrants such attempt. In the management of spontaneously ruptured kidneys, however, our aim should be the removal of the diseased kidney (provided the other kidney shows sufficient function to carry on), combined with proper drainage of the perinephric space. This procedure cannot always be carried out as the patient with spontaneous rupture of a diseased kidney is acutely ill with underlying chronic renal disease which will not always warrant extensive surgery. Furthermore, the removal of a chronically diseased, densely adherent kidney may prove time consuming and inadvisable for an acutely ill patient. Incision and drainage should therefore be the procedure of choice in many instances with a secondary nephrectomy at a later date.

The case reported below was hospitalized for only two days and never recovered sufficiently for even an attempt at exploration and drainage of the perirenal space.

CASE REPORT

Mrs. E. J., aged sixty-three, was admitted to the Rhode Island Hospital on August 24, 1942, at which time she complained of aches in the right flank and costovertebral angle, weakness,



FIG. 1

nausea, loss of weight and intermittent hematuria. There was no history of fever or chills at any time. The patient's examination in August, 1942, revealed a blood pressure of 145/60 and there was distinct enlargement of the right kidney with slight tenderness over the right



FIG. 2

flank and costovertebral angle. The heart was enlarged to the left side. Roentgen examination of the urogenital tract by a preliminary roentgenogram showed enlargement of the left kidney and a large staghorn calculus in the region of the renal pelvis and calices and several small discrete calculi in the lower pole of the kidney. The right kidney was poorly outlined and there was an enormous calcified mass with lobulated borders which probably represented a conglomeration of innumerable small calculi occupying practically the entire kidney (Fig. 1 and 2). Intravenous pyelography showed considerable delay in excretion of dye on the left side with evidence of a moderate degree of hydronephrosis. There was no excretion of dye on the right side.

The patient left the hospital against advice and before the clinical studies could be completed. No operation was performed at that time. The patient had no medical care until December, 1945, when she was admitted to the hospital for the second time because of nausea, progressive weakness and drowsiness. Subsequently she developed profuse vomiting and became comatose. There was swelling of both legs and moderate dyspnea for two weeks prior to her last hospitalization. The patient's physical examination revealed the following findings: undernourished, markedly anemic patient in very poor general condition. Patient comatose, reflexes markedly diminished. Skin dry and pasty with marked edema of both legs. The breath was urinous. Chest revealed scattered moist rales at both bases, the heart was enlarged to the left side and a faint systolic murmur was present over the apex. The abdomen was distinctly tender on the right side anteriorly and over the right costovertebral angle. No definite muscular rigidity over the abdomen. Urinalysis showed traces of albumin, no sugar, occasional leukocytes and phosphates. Urea nitrogen was 63 mg. per 100 cc. and creatinine 3.2 mg. per 100 cc., the blood sugar 316 mg. per 100 cc. The blood showed an erythrocyte count of 1.5 million, leukocyte count of 13,050 with 80 per cent polymorphonuclears, 18 per cent lymphocytes, and 2 per cent monocytes; there was anisocytosis, achromia, polychromasia, and younger forms of neutrophil cells.

Cystoscopy and retrograde pyelography were performed and showed a chronically inflamed bladder with normal ureteral orifices. Preliminary roentgenograms of the urinary tract were

taken before and after catheterization of the right ureter, and retrograde pyelograms were made in anteroposterior and lateral positions. The preliminary roentgenograms of the abdomen showed lack of proper visualization of the renal shadows. On the left side there was a large, irregular, ill defined renal calculus of the staghorn type, and in the region of the renal pelvis there was an ovoid calculus measuring 3 by 2 cm. on the film. There were no calculi in the course of the left ureter.

On the right side the renal structure appeared to be replaced by a conglomerate collection of innumerable round calculi measuring 7 mm. in diameter, and just below the normal confines of the lower renal pole, there was a smaller group of similar shadows which were not massed as close together as those within the kidney. In the pelvis, there were six widely separated calculi of the same size and density as the renal shadows. These could have been within a markedly tortuous, dilated ureter, in the bladder, or possibly within the pelvic cavity, outside the urinary tract. In addition to these calculi, there were several small calcifications, only a few millimeters in diameter, situated in the lower portion of the right renal pelvis.

Retrograde pyelograms (Fig. 3 and 4) showed a moderate ptosis of both kidneys. The position of the calculi in the pelvis had varied but the position of the remaining calculi was essentially the same as on the preliminary films. The tip of the ureteral catheter was opposite the fifth lumbar space, where there was an abrupt angulation of the ureter. The pelvic portion of the ureter had a normal course, but the ureter above the point of angulation was deviated medially and anteriorly, and also dilated. Considerable amounts of dye were injected into the renal pelvis and revealed loss of all anatomical structures. There was no extravasation of dye from the kidney. The calculi in the pelvis were not within the bladder, or ureter, and therefore it appeared evident that rupture of the kidney had occurred, releasing numerous calculi into the retroperitoneal cavity, from the perinephric space, along the psoas muscle and downward into the pelvis.

The patient's condition did not improve and fluids were administered intravenously and oxygen given. The original blood sugar of 316 mg. did not definitely establish a diagnosis of diabetes as the patient had received glucose intravenously the night preceding the blood test. The patient's condition was too poor to



FIG. 3

consider operation within the next twenty-four hours. She died on December 8, 1945, and permission was obtained to perform an autopsy on the abdomen.



FIG. 4



FIG. 5

The postmortem findings were: No fluid in the peritoneal cavity and no adhesions. The splenic capsule is covered by fibrinous exudate. The parenchyma is soft and dark brown, suggesting septic infection. On section there is increased fibrosis. The head of the pancreas is involved in a large mass surrounding the renal parenchyma. The cecum is densely adherent to the perinephric capsule anteriorly and is located in the mid-flank. The ascending colon is closely attached to the hilus of the kidney, but can be dissected from the pelvis without establishing a fistulous opening between the renal pelvis and the intestine. Exploration of the intestine reveals no intrinsic pathology. The liver shows normal appearing parenchyma on section.

The right kidney weighs 275 grams. The parenchyma has disappeared completely. The renal pelvis is markedly dilated and contains about 200 bronze pellets measuring 0.5 cm. each. The renal pelvis has apparently ruptured posteriorly into the perinephric capsule and psoas muscle. An abscess extends into the pelvis as far down as 2 cm. above the obturator foramen. This abscess contains yellow fetid pus and a number of stones similar to the others. The ureter is patent throughout (Fig. 5 and 6).

The left kidney weighs 350 grams. On section there is found a large capsule, and the remaining renal parenchyma measures about 1 cm. in cross section. It is composed mostly of cortex, the medulla has disappeared. The calices are markedly dilated. The ureter contains puru-

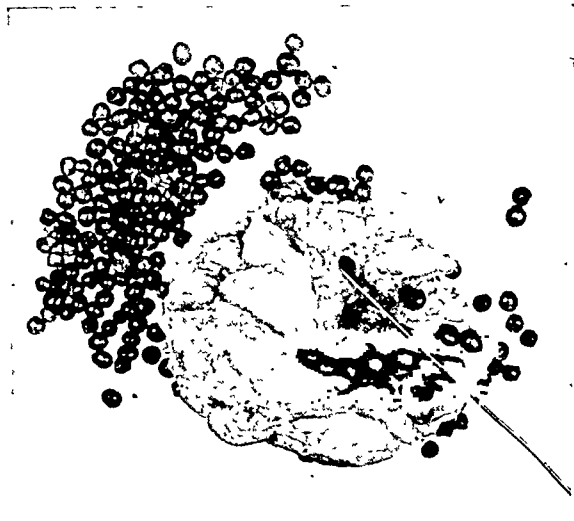


FIG. 6

lent material. The bladder is small, the wall markedly thickened, the mucosa succulent, yellowish red. There are several ulcerations in the bladder.

The aorta is markedly sclerotic and tortuous and there are ulcerations throughout its extent in the abdomen.

Pathological diagnosis: Bilateral nephrolithiasis and chronic pyelonephritis; rupture of the right renal pelvis, right perinephric abscess.

SUMMARY

The clinical, roentgenological, and post-mortem findings are reported in a case of bilateral nephrolithiasis with spontaneous perforation of the right renal pelvis with an unusually large number of stones in the perinephric space and lower pelvis.

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REFERENCES

1. ABESHOUSE, B. S. Rupture of kidney pelvis. *Surg., Gynec. & Obst.*, 1935, 60, 710-729.
2. BLOCK, W. Perirenale Urincyste nach Steinperforation des Nierenbeckens. *Ztschr.f.Urol.*, 1932, 26, 788-796.
3. CRABTREE, E. G. Pararenal pseudo-hydronephrosis. *Tr. Am. A. Genito-Urin. Surgeons*, 1935, 28, 9-40.
4. DOURMASHKIN, R. L. Stone in ureter complicated by rupture of kidney and subcapsular extravasation of urine. *Urol. & Cutan. Rev.*, 1932, 36, 670-673.

5. FERRIER, P. A., and KNIGGE, W. Ruptured kidney. *J. Urol.*, 1943, 49, 457-459.
6. FLOYD, E., and PITTMAN, J. L. Spontaneous rupture of kidney due to encysted calculus. *J.A.M.A.*, 1931, 97, 98-99.
7. HENLINE, R. B. Spontaneous rupture of kidney. *J.A.M.A.*, 1924, 83, 1411.
8. JAMES, T. G. I. Intraperitoneal rupture of calculous pyonephrosis. *Brit. J. Urol.*, 1933, 5, 386-387.
9. JEWETT, H. J. Spontaneous rupture of hydronephrotic kidney associated with primary carcinoma of ureter. *J. Urol.*, 1940, 43, 664-668.
10. LARKS, G. Spontaneous rupture of hydronephrosis. *Brit. J. Surg.*, 1942, 29, 354-356.
11. LAZARUS, J. A. Spontaneous perforation of renal calyx resulting in urinary fistula, following stricture of ureter. *Urol. & Cutan. Rev.*, 1934, 38, 316-318.
12. LOWSLEY, O. S., and MENNING, J. H. Treatment of rupture of kidney. *J. Urol.*, 1941, 45, 253-271.
13. MATHÉ, C. P. Spontaneous rupture of kidney. *Urol. & Cutan. Rev.*, 1932, 36, 605-614.
14. MATHE, C. P., and OVIEDO, G. F. Spontaneous rupture of hydronephrotic sac secondary to ureteral stone. *California & West. Med.*, 1927, 26, 790-795.
15. MOORE, N. S., and MCCARTHY, H. H. Perirenal abscess with extension into right pleural cavity following rupture of right renal pelvis. *J. Urol.*, 1944, 52, 17-22.
16. NITSCHKE, P. H. Spontaneous rupture of kidney. *Urol. & Cutan. Rev.*, 1938, 42, 475-479.
17. ROGERS, J. W. Diagnosis of spontaneous rupture of kidney pelvis by means of intravenous urography. *J. Urol.*, 1936, 36, 105-110.
18. SALVIN, A. A. Spontaneous rupture of hydronephrotic kidney secondary to calculous obstruction of ureter. *Am. J. Surg.*, 1938, 41, 288-292.
19. SCHMIDT, A. Spontanrupture einer infizierten Sackniere. *Ztschr. f. Urol.*, 1931, 25, 93-97.
20. SPEESE, J. Perirenal hematoma. *Surg., Gynec. & Obst.*, 1913, 16, 571.
21. WADE. Spontaneous rupture of kidney with perirenal hemorrhage in acute nephritis. *J. Med. Research*, 1915, 32, 419.
22. WALLENSTEIN, S. Urinary extravasation at varying levels, with report of 16 cases. *Med. J. & Rec.*, 1928, 127, 525; 592.
23. WOOD, W. Q. Spontaneous rupture of hydronephrosis. *Brit. J. Surg.*, 1923, 10, 574.



THE USE OF HIGH VOLTAGE ROENTGEN THERAPY IN THE TREATMENT OF AMENORRHEA AND STERILITY IN WOMEN*†

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FOR the purpose of this study I have divided the cases treated by me into two groups: the unmarried patients who sought relief from amenorrhea; the second group, married women who sought relief from amenorrhea and sterility or for sterility alone.

Amenorrhea may be due to numerous and varied conditions. In some cases it is due to congenital or pathological malformations. For these, irradiation is of no avail. Irradiation is useful in those cases where amenorrhea is a result of physiological dysfunction.

The amenorrheic or sterility patient does not come to the radiation therapist directly. She is always referred by her physician or gynecologist, and only when every other method of treatment had been tried and proved unsuccessful. In some cases even artificial insemination was tried but failed.

In nearly every case some sort of endocrine, or drug therapy had been tried and proved unsuccessful. In many instances hormone injections produced vaginal bleeding, probably from a stimulated uterine mucosal hyperemia rather than true menstruation, and when the injections were discontinued no further bleeding occurred. Irradiation, on the other hand, when properly used produced normal menstruation and permitted normal pregnancy in the previously infertile woman.

Just how irradiation works to correct amenorrhea and sterility is still not definitely known. In the early days of radiation therapy only the suppressive effects of

roentgen rays were recognized and only later were the biological and physiological sequences following irradiation an indication of a stimulation effect.

In 1905 Halberstaedter⁵ first called attention to the selective action of the roentgen ray on the ovary. It may then be asked, is the relief of amenorrhea following roentgen treatment a direct stimulation effect based on Halberstaedter's selective action findings? Taylor¹³ is of the opinion that roentgen rays have such a stimulating effect. Rubin,¹¹ also believes that the relief of amenorrhea and sterility following roentgen treatment is probably a general reaction to a stimulative effect. The following cases responded to roentgen therapy to the ovaries alone and seem to bear out this assumption.

CASE I. Mrs. G. F., aged twenty-nine, was referred for treatment of sterility on April 8, 1927. Menstruation occurred at thirteen and was always irregular and did not improve following marriage at twenty-six. Her last menstrual period occurred in February, 1927. Following a course of medical treatment she was given roentgen therapy administered only to the ovaries on April 8, 15 and 22, 1927. Following irradiation she menstruated regularly for two months, became pregnant and was delivered of a normal baby boy on March 15, 1928.

CASE II. Mrs. M. B., aged twenty-four, was referred for treatment of sterility on October 10, 1927. Menstruation began at sixteen, was always irregular occurring at three to four month intervals. The last menstrual period occurred on July 4, 1927. She was married at

* Presented at the Forty-seventh Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 17-20, 1946.

† The statistics herein presented have been augmented since this paper was presented in September, 1946.

twenty-one, three years before treatment. She had received numerous courses of endocrine therapy and a therapeutic application of the insufflation test without results. Treatment was administered on October 10, 17 and 24, 1927, only to the anterior (100 r) and posterior (150 r) ovarian areas. Following treatment she menstruated regularly until December, 1927, became pregnant and in August, 1928, was delivered of a normal baby girl.

Do the roentgen rays stimulate an undeveloped uterus? The following case suggests such an action.

CASE III. Mrs. F. S., aged twenty-four, was referred to me on November 3, 1926, for sterility. Menstruation began at thirteen, was regular at first then gradually became irregular occurring but three or four times per year. Her last menstrual period was in August, 1926. She married at twenty-two with no improvement of the condition. She was of moderate size. The referring gynecologist reported she had an undeveloped uterus. Medication failing to relieve the sterility, she was referred for roentgen therapy. Treatment was given only to the anterior (150 r) and posterior (100 r) ovarian areas, on November 3, 10 and 17, 1926. She responded well, menstruated in December, 1926, became pregnant in January, 1927, and was delivered of a normal baby boy on August 2, 1927.

Do the roentgen rays act in a mechanical manner? We know that one effect of the rays is the production of hyperemia with subsequent swelling of the tissues and in this way perhaps they mechanically cause rupture of an existing ovarian cyst. Stein and Leventhal¹² believe this is the reaction following roentgen therapy. Such cystic ovaries tend to inhibit proper menstruation; when they are ruptured menstruation should follow.

The following 2 cases tend to bear out this assumption of roentgen-ray action.

CASE IV. Mrs. M. G., aged thirty-four, referred on January 24, 1929, for sterility. She menstruated at eleven, always irregular and scanty. In 1920 she was operated upon with the hope of correcting her irregularity. A right cystic ovary and an infantile uterus were found. Menstruation was not improved. However, she

was married five years later at the age of thirty. There was no change in her condition and, following failure of all other treatment, she was referred as a last resort to me for irradiation. Treatment was administered over the ovaries and the pituitary on January 24, 31, and February 7, 1929. She responded well and menstruated regularly. On December 1, 1929 she was delivered by cesarean section of a normal baby girl.

CASE V. Mrs. F. C., aged twenty-seven, was referred on March 17, 1941 for sterility. She menstruated at thirteen, always irregular. She married at twenty-four without relief. In 1940 she was operated upon and was told she had a left cystic ovary. Surgery failed to relieve her irregularity or sterility. Roentgen treatment was administered on March 17, 24 and 31, 1941. She responded well to treatment, menstruated regularly, and on August 16, 1942, was delivered of a normal baby girl.

Rock and his co-workers¹⁰ believe that the beneficial effect is produced by roentgen-ray destruction of one or more follicles which have matured but which failed to rupture and progress through a normal corpus luteum stage, thus upsetting the normal menstrual periodicity. That the persistent corpus luteum may prevent menstruation is definitely recognized and Allen¹ noted that surgical removal of a persistent corpus luteum restored menstrual function. Roentgen therapy may perhaps act in a similar manner as noted in the following case.

CASE VI. Mrs. B. E., aged twenty-nine, was referred for secondary sterility on April 6, 1927. She already had one child six years of age but was unable to conceive again. Menstruation began at eleven and was always irregular; the last period was in March, 1927, the previous one in October, 1926. She married at twenty-two. She was obese and the uterus was retroverted. Roentgen treatment was administered to the anterior (100 r) and posterior (150 r) ovarian areas on April 6, 13, and 20, 1927. Normal menstruation followed until July, 1927, when she became pregnant and on April 4, 1928, was delivered of a normal baby boy.

CASE VII. Mrs. H. S., aged thirty, referred for amenorrhea and sterility on November 9, 1944.

Menstruation began at fifteen, always irregular, three times per year. She was married at twenty-four and two years later gave birth to a baby—1940, and did not menstruate subsequently for four years. Roentgen treatment was administered on November 9, 16 and 23, 1944. Normal menstruation followed, she became pregnant again and on October 4, 1945, gave birth to a normal baby girl.

What part does the pituitary play in amenorrhea and sterility and in what way does roentgen therapy bring about such influence?

That the pituitary plays an important part in the normal menstrual function has been definitely demonstrated both by laboratory and clinical investigators. About 7 per cent of sterility cases are due to pituitary dysfunction. Just how roentgen rays act on the pituitary is as yet not known. Although roentgen irradiation to the pituitary alone has proved efficacious in some cases, it does not account for the favorable results in all our cases for some were treated only through the ovaries.

Béclère² was the first to note the favorable effect of roentgen therapy to the pituitary on menstrual function. Werner¹⁴ noted a definite stimulation of menstruation following irradiation of the pituitary. Borak³ noted that irradiation of the pituitary ameliorated the climacteric symptoms of early menopause. It is still a moot question whether or not the pituitary can be affected by irradiation in such a manner as to induce hormonal effects in order to bring on ovulation.

Crossen and Crossen⁴ state that ovarian function is definitely activated by the pituitary. Johnstone⁷ states that the cause of amenorrhea is highly complex and must be something that activates the whole triangular mechanism of the pituitary, ovary and uterus. At the present time we are inclined to attach much importance to the pituitary as a factor in controlling menstrual function. The following cases suggest action from roentgen-ray effect on the pituitary for both these cases had hypopituitary features.

CASE VIII. Mrs. A. G., aged twenty-seven, was referred on October 27, 1929, for sterility. Menstruation began at seventeen and was always irregular, at three month intervals. The last period occurred on July 10, 1929. Periods were always accompanied with severe pain. She was short, obese and weighed 167 pounds. She was married at twenty-four and had not conceived. Other treatments having failed, she was referred for roentgen therapy. Treatment was given to the ovaries (anterior, 100 r; posterior, 150 r) and pituitary (215 r) on October 27, November 3 and 10, 1929. She menstruated following treatment and became pregnant and gave birth to a baby girl in July, 1930.

CASE IX. Mrs. L. R., aged twenty-seven, was referred on September 28, 1943, for sterility. She was very obese and had been taking thyroid, gr. ii, per day for a very long period. Menstruation began at thirteen and was always irregular; the last period was in 1936 or 1937, that is an amenorrhea for about seven years. She married at twenty-four but had not been able to conceive. She had had numerous endocrine injections and a curettage which was reported as "anovulatory mucosa." Roentgen therapy was administered on September 28, October 5 and 12, 1943. Following treatment she menstruated regularly for four months, became pregnant and on October 11, 1945, gave birth to a normal baby girl.

In some cases, the action of the roentgen rays may be due to an effect on the endocrine system as a whole, such as was noted by Hutton⁶ and his associates in their study of the effect of irradiation in the treatment of hypertension.

In some cases, although menstruation was apparently regular, the woman was unable to conceive until roentgen therapy was administered. Such action of the roentgen rays we believe might be considered as a general endocrine stimulation effect.

Such a response is illustrated by the following cases.

CASE X. Mrs. A. H., aged thirty-two, referred for sterility on July 24, 1941. Menstruation began at thirteen and was regular. She married at twenty-seven but in spite of medical treatment did not become pregnant. There was no gynec-

logic pathology. Tubes were patent. After five years of sterility and failure of other measures she was referred for roentgen therapy. Treatment was given to the ovaries and pituitary on July 24, 31 and August 7, 1941. She responded well and gave birth to a baby girl on March 9, 1945.

CASE XI. Mrs. M. S., aged twenty-five, referred for sterility on October 21, 1942. Menstruated at thirteen regularly. Married at the age of twenty-two and continued to menstruate regularly but although anxious to have a child did not become pregnant. There was no gynecologic abnormality and the tubes were patent. Medication failed to relieve the sterility and she was referred for roentgen therapy. Treatment was administered to the ovaries and the pituitary on October 21, 28 and November 4, 1942. She menstruated regularly following treatment until February, 1943, when she became pregnant and was delivered of a normal baby girl on November 29, 1943.

In my opinion, although we are not certain what may be the specific action of the roentgen rays, it is a stimulation effect. And although we do not know exactly how this stimulation effect takes place roentgen therapy as used by me has successfully relieved amenorrhea and sterility.

During the course of the past twenty-one years, 1925-1946, there were 338 cases referred to me in private practice for the treatment of amenorrhea and sterility; 33 were unmarried and 305 were married women. Of these 1 case refused treatment and 3 cases had but one treatment and failed to complete the course.

Treatment in all instances was solely by irradiation with high voltage roentgen rays administered to the ovaries alone or to the ovaries and the pituitary. In a few instances roentgen irradiation was also given to the thyroid.

The factors used were 200 kv., 4-5 ma., with 0.5 mm. Cu plus 1 mm. Al filter, with a target distance in the early cases of 30-40 cm. and for the past ten years at 50 cm. distance. Treatment was directed through pelvic fields of 8 by 10 cm., 9 by 12 cm., or 10 by 15 cm., and through a 6 by 8 cm.

field to the pituitary. Treatment was administered as follows: The first day 50 roentgens was given to the anterior right and left ovarian fields and 75 r to the anterior pituitary area; one week later 75 r was given to the anterior pituitary area and 75 r was given to the posterior right and left pelvic ovarian fields; one week later the anterior right and left pelvic ovarian fields were given 50 r and the anterior pituitary field 75 r. All doses were measured in air.

Occasionally in a very stout patient we add an additional or fourth treatment to the posterior pelvic areas. It is very essential that the roentgen therapy be delivered to the patient at a milliamperage of 5 to 10, never higher. The dose, measured in air, delivered to each part must be timed exactly. For even one minute overdosage may mean the difference between success and failure.

The dose into the ovaries must be between 10-14 per cent of the given dose. Perfect positioning of the localizer must be had in every case and this requires placement by the therapist himself. Only attention to these details produces good results.

As a rule, only one series of treatments was given. However, in 2 instances this rule was not adhered to, because of the insistence of the patients, who previously had been relieved by roentgen treatment and again demanded relief when they ceased to function normally a second time. The following cases illustrate the result of repeated treatment.

CASE XII. Mrs. D. O., aged twenty-three when she first came to me on September 28, 1938. Menstruation began at eleven but appeared only once or twice per year. She had medical care without result. Married at twenty-one with no change. Further medical treatment was given without result. She was of heavy build with much hair over the limbs and pelvis. Roentgen treatment was administered on September 29, October 6 and 13, 1938. She responded well and became pregnant and was delivered of a normal baby girl August 7, 1939.

She remained well and menstruated normally

for one year following birth of the baby, then became irregular, every three to four months, and the last period was in November, 1944. On January 9, 1945, she requested roentgen treatment in order to have another child. I was loath to again administer roentgen treatment; however, because the patient was most anxious and the Rubin test proved the tubes patent, treatment was administered. One treatment was given on January 9, 1945, and then because no result was achieved treatment was again given in the regular manner on April 13, 20 and 27, 1945. She responded immediately, became pregnant and was delivered of a normal baby girl on December 11, 1945.

CASE XIII. Mrs. A. S., aged twenty-eight, first came to see me on October 24, 1940. Menstruated at thirteen, irregular. Married at twenty-five and had one child following marriage after which menstruation ceased. Medication of all sorts was unavailing. Roentgen treatment was administered on October 24, 31 and November 7, 1940. The result was good and she was delivered of a normal baby girl on May 5, 1942, but it was followed by cessation of menstruation. In October, 1943, she again requested treatment and after much persuasion I again administered roentgen therapy. Treatment was given on October 18, 25 and November 1, 1943. The patient responded well and was delivered of a normal baby boy on March 10, 1945.

Again menstruation stopped completely. In September, 1945, she again requested therapy. I was extremely interested in this case to see whether therapy could be effective once again, a third time, and because all medication given by her physician failed to correct the amenorrhea. Accordingly roentgen treatment was administered on September 21, 28 and October 5, 1945. Menstruation followed but unfortunately on December 7, 1945, she was stricken with anterior poliomyelitis and menstruation ceased. On March 26, 1946, she notified me that menstruation had occurred on March 22, 1946, and lasted for three days normal flow.

There is no doubt that the younger the patient the better the result from treatment. In this series, in the unmarried group the youngest was sixteen and the oldest thirty. In the married group the youngest was eighteen and the oldest forty-five. The largest number of married

patients seeking relief were between the ages of twenty-seven and thirty. Of the total of 305 married women 111 were in this age group.

In spite of the adverse reports of abnormalities produced experimentally by irradiation in animals, I have only in one instance, which I reported in 1932⁸ seen an abnormal child born of an irradiated mother which abnormality, however, was not proved to be due to irradiation.

While this treatment is not as effective in unmarried women it is harmless, and once the menstruation is restored such patients will when subsequently married give birth to normal children. The following case is illustrative of such a happening.

CASE XIV. On May 13, 1929, there was referred to me a young woman (M. M.), aged twenty-one, who was suffering from periods of amenorrhea and severe dysmenorrhea when she did menstruate. Medical treatments of all sorts failed to regulate the periods or relieve the distress. Menstruation began at eleven, was always irregular at about three month intervals. Her last period was on February 7, 1929. Roentgen treatment was administered on May 13, 20 and 27, 1929, to the ovaries and the pituitary. Menstruation became regular at monthly intervals and occurred without pain. In 1931 she married (at twenty-three) and continued to menstruate regularly, became pregnant and gave birth to a normal baby boy on August 4, 1932. On February 7, 1934, she gave birth to a second boy. She continued to function normally and in September, 1936, had an ectopic pregnancy. She now menstruates regularly.

The period of sterility for which treatment was requested varied from several months to many years. The following cases represent an extended period of sterility relieved only by roentgen therapy.

CASE XV. Mrs. L. S., aged thirty-three, was referred for irregular menstruation and sterility on January 13, 1925. She was married at the age of fifteen but menstruation began at eighteen and was always irregular. She wished to become pregnant but in spite of all treatments, including surgery and special European treatments, was unable to conceive. As a last resort she was referred for roentgen therapy. Treatment was

administered on January 13, 21 and 30, 1925. She responded well, became pregnant and gave birth to a baby boy on March 19, 1926, and subsequently a baby girl on March 7, 1928, and another boy on April 13, 1930. On February 30, 1931, she miscarried but has menstruated normally since then.

CASE XVI. Mrs. E. R., aged thirty-three referred for irregular menstruation and sterility on January 24, 1944. Menstruation began at thirteen, was always irregular, three to six times a year. Her last period occurred on January 11, 1944. She married at twenty and for thirteen years remained sterile. Her husband was tested and found normal. After all other treatments failed, even abroad by foreign specialists, she was referred for roentgen therapy. Treatment was administered to the ovaries and pituitary on January 24, 31 and February 7, 1944. She responded well and became pregnant in June, 1945, and gave birth to a normal baby boy on April 3, 1945.

This study comprises a review of 338 cases. Four of these did not complete the prescribed course of therapy; therefore, only 334 cases were fully treated. Of these 33 were unmarried and 301 were married.

Two hundred and seventy-four cases were followed up; 12 unmarried and 48 married cases were not traced. Of the 274 cases followed, favorable results were achieved in 12 unmarried and 198 married women; and in 9 unmarried and 55 married women treatment failed.

In the favorable result group of 198 married women, after regulation of menstruation 90 became pregnant and went to term and delivered 101 normal children (there was one set of twins); 45 boys and 56 girls. There are 4 women still pregnant. Thirty-two additional cases became pregnant following treatment, of which 18 miscarried, several more than once, 2 had ectopic pregnancies, 1 gave birth to a still-born child, 3 gave birth to normal children but died shortly thereafter, 6 aborted, some intentionally, there was 1 abnormal birth, and 1 case was deliberately therapeutically aborted.

Of the 301 married women treated, 34 had previous miscarriages, 16 had abortions,

7 had stillbirths, 1 had an ectopic pregnancy, 3 had children who died at birth, 34 had one or more live children before irradiation.

Of those who became pregnant after treatment 20 had more than one child after treatment (so far recorded).

The total who had normal full term pregnancies after treatment—90.

Of those who responded successfully and bore children following irradiation, 6 had previously borne children and 1 of these also miscarried, 7 had miscarriages, 2 had stillbirths, 1 had an abortion. One case which responded had miscarried before irradiation and miscarried twice following irradiation.

Based upon my experience of over twenty years of more than 300 women suffering from amenorrhea and sterility, I feel warranted in reiterating my previous conclusions⁹ that roentgen irradiation, properly administered, is harmful neither to the mother nor to the offspring and that it has proved a valuable therapeutic procedure for the treatment of amenorrhea and for the relief of sterility.

In conclusion, I wish to add one word of caution. This type of irradiation, to secure effective results, must be administered only by the trained and experienced radiologist whose apparatus is properly and carefully standardized to permit accurate dosage measurement.

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REFERENCES

1. ALLEN, E. Physiology of estrogenic principles. *J.A.M.A.*, 1935, 104, 1498-1502.
2. BÉCLÈRE, A. *Paris méd.*, 1926, 13, 97.
3. BORAK, J. Die Röntgentherapie und die Organotherapie bei innersekretorischen Erkrankungen. III. Wechselbeziehungen der Drüsen mit innerer Sekretion im Klimakterium. *Strahlentherapie*, 1925-1926, 21, 31-55.
4. CROSSEN, H. S., and CROSSEN, R. J. Amenorrhea; menorrhagia; metrorrhagia; delayed menopause. *Am. J. Surg.*, 1936, 33, 345-368.
5. HALBERSTAEDTER, L. *Berl. klin. Wchnschr.*, 1905, 42, 64-66.

6. HUTTON, J. H. Recent advances in endocrine diagnosis and treatment. *J. Lab. & Clin. Med.*, 1936, 21, 736-742.
7. JOHNSTONE, R. W. New physiology of menstruation and its practical applications in obstetrics and gynecology. *Am. J. Obst. & Gynec.*, 1930, 19, 167-180.
8. KAPLAN, I. I. Report of case of abnormal fetus following radiation of mother. *Am. J. Obst. & Gynec.*, 1932, 23, 426-427.
9. KAPLAN, I. I. 1940 Year Book of Radiology. Year Book Publishers, Inc., Chicago, pp. 261-272.
10. ROCK, J., BARTLETT, M. K., GAULD, A. G., and RUTHERFORD, R. N. Effect of subcastrative roentgen therapy on ovarian physiology. *Surg., Gynec. & Obst.*, 1940, 70, 903-913.
11. RUBIN, I. C. Sterility associated with habitual amenorrhea relieved by x-ray therapy. *Am. J. Obst. & Gynec.*, 1926, 12, 76-88.
12. STEIN, I. F., and LEVENTHAL, M. L. Amenorrhea associated with bilateral polycystic ovaries. *Am. J. Obst. & Gynec.*, 1935, 29, 181-191.
13. TAYLOR, H. C., JR. Relation of chronic mastitis to certain hormones of the ovary and pituitary and to coincident gynecological lesions. Part I. Theoretical considerations and histological studies. *Surg., Gynec. & Obst.*, 1936, 62, 129-148. Part II. Clinical and hormone studies. *Ibid.*, 562-584.

DISCUSSION

DR. WILLIAM HARRIS, New York, N. Y. Dr. Kaplan should be congratulated on his lucid and timely paper. It is heartening to hear again of man's successful effort to aid in the creation of life rather than the discovery of new machines and weapons to destroy it. Although doubt may have existed previously as regards the efficacy of roentgen therapy for sterility, Dr. Kaplan's series of cases is large enough to make it statistically significant.

There was considerable interest in this treatment during the twenties, but its use has been greatly eclipsed and narrowed during the last fifteen years following the discovery of new and potent endocrine products. Up to the present, no endocrine products other than thyroid extract have been found to have any value in sterility (functional), and this only in a small percentage of patients who showed some of the stigmata of hypothyroidism.

Another factor which played a role in the general apathy toward roentgen therapy for sterility was the possible chromosomal damage inferred from the work of Muller and other geneticists. Thus far there has been no such

evidence of damage in human beings. Naturally, a distinction must be made between irradiating a fertilized ovum and fetus and the treatment of a sterile patient. In the former case, there is no question regarding lethal damage that can be produced by irradiation.

The question of harmful effects on the second generation cannot as yet be determined by Dr. Kaplan's study, but this information will no doubt be forthcoming soon. I know of two radiologists who, after a number of years of sterility and azoospermia due to exposure to radiation, had a return of normal spermatogenesis, and each became the parent of two children who later had normal children of their own. Further light will probably be thrown on this important subject in some years when the radiation effects of atomic bombs dropped on Hiroshima and Nagasaki can be evaluated in light of possible chromosomal damage.

The fact that many of the patients had only one child after treatment, would make me hesitate to treat unmarried patients whose only complaint is oligomenorrhea or complete amenorrhea.

As regards the mechanisms underlying the successful use of roentgen rays in these patients, our information is meager and theoretical. Further studies to determine the presence of absence of ovulation by endometrial biopsies, etc., might prove helpful. In some cases, the effect of roentgen rays on the lipoids of a persistent corpus luteum forms an intriguing hypothesis. I believe that the word "stimulating" is a poor choice because irradiation is always destructive in some degree. May I suggest the "alterative" effect of radiation until we have a more precise term.

This treatment deserves greater popularity and should be called again to the attention of gynecologists and obstetricians who are at present so often helpless in the treatment of sterility.

Again may I thank Dr. Kaplan for recalling this important subject to us and to congratulate him on his excellent results.

DR. KAPLAN (closing). I thought that the geneticists might say something. Dr. Henshaw asked me a few questions yesterday which I tried to answer and maybe I answered them properly.

We don't know exactly everything from the genetic standpoint. I am hoping to have a second generation baby pretty soon, from the first

young woman to get married in the group. I was unfortunate to have only boys born in the first batch. Everybody wants boys, but as yet none have reported marriage or progeny.

However, from this girl who is now married I expect to see a baby and then I can tell you about the second generation, but only in the one instance in my series about which I published a report has there been an abnormal child.

As to the treatment, no case comes to me who has not already been to the gynecologist. I do not take the cases direct, everything has been done before they reach me so I can't say anything about the gynecological reasons for their not having a baby.

Dr. Harris brought up the point about repeating the treatment. He is absolutely right. I was loath to repeat it. But these cases had been treated with a minimum of a year in between courses, and I thought perhaps it would work and, as you see in two cases it did work.

I have a third one that has become pregnant. I don't advise repetition of treatment. It is a one-treatment method of relieving sterility.

How does irradiation work? I used the word

"stimulation" because I have no other word. It may be better, as Dr. Harris suggests, to say that it has a regulatory effect. I am not quite sure. How many children will they have after this? I did not give that figure but I will check on that in the next report. There are at least 30 per cent of these women who have had several children after irradiation so it isn't just a one-baby effect at all, and it is a worth while procedure.

There is one thing I want to call attention to. This treatment is something that only the trained radiologist can do. It cannot be rented out by the hospital superintendent, as they are doing with radium, nor can it be given in the form of a little x-ray here or there. It must only be given by the trained radiologist and I would like to see more of you use it because it is worth while.

QUESTION: What percentages of your total cases become pregnant?

DR. KAPLAN: Over 50 per cent of the 198 married women traced. There were 126 pregnancies, 90 successful and 32 incomplete, and 4 still pregnant. It is a good percentage of those that were traced.

THE TREATMENT OF KELOIDS BY IRRADIATION AND ELECTROSURGERY*

By GEORGE E. PFAHLER, M.D., AND GEORGE P. KEEFER, M.D.

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KELOIDS have been treated by irradiation during the past forty-seven years. Ullmann, Albers-Schönberg, Morton, Pusey, and Allen were the first to report the usefulness of roentgen rays in the treatment of keloids and hypertrophic scars as early as 1900. Williams was the first to employ radium for this purpose in 1910. Wickham and Degrais, at about the same time, reported the successful treatment of a number of cases.

One of us (G.E.P.) presented a paper before the Section on Dermatology and Syphilology, at the 71st Annual Meeting of the American Medical Association, April, 1920, in which he recommended the use of radium combined with excision in the treatment of keloids.

Keloids may range in size from a slight thickening of scar tissue and from an area a few millimeters in diameter to tumors as large as an adult fist, or even larger. There may be keloidal bands which cause disfigurement by drawing the soft parts out of position, such as occurs about the mouth or eyelids (see Fig. 1). Keloids may be red, brown or the normal color of the skin, and even paler than the skin. There may be a telangiectasis before receiving any irradiation. At times, they are pedunculated. They may be sensitive to pressure. Keloids that have existed for a long time and those that have developed very slowly are likely to be firm and even hard to the sense of touch. Recent keloids and those of comparatively rapid growth are rather less hard to the palpating finger.

The underlying constitutional cause of the formation of keloids we believe is not known, but the exciting cause is known to the members of this Society. It is traumatism, and the traumatism does not always

refer to some operative procedure. We have repeatedly seen keloids develop on the basis of a small "pimple" which has been scratched by the patient. This occurs especially in the upper sternal region. There must also be some local factor which is active in the etiology, for we have noticed in the removal of a number of moles from a patient by electrodesiccation that one or more of these show hypertrophy when other lesions on the same patient, and apparently of the same character, show no such hypertrophy. This indicates the cause is not merely a constitutional one.

Since we do not know the actual constitutional or local cause, we will deal in this presentation only with the treatment of the lesion. Usually the patient seeks relief because of deformity or for cosmetic reasons, but occasionally pain is a prominent symptom and brings the patient for treatment. In other cases, the keloid may cause actual mechanical obstruction as when they occur on the feet and interfere with the wearing of shoes.

MacKee says, "Today there is pretty general agreement that irradiation alone in most cases, and combined with surgery in some cases, constitute the best method of combating keloids and hypertrophic scar. It is the only method of treatment that insures against recurrence."

Keloids or hypertrophied scars are difficult to treat. It requires much patience on the part of both the patient and the physician. So far as is known, the roentgen rays and radium are the only two agents which will arrest the disease or cause it to disappear. If these agents are used thoroughly when the scar begins to hypertrophy, there will probably be no need of combining excision or electrosurgery with the radio-

* Presented at the Twenty-ninth Annual Meeting, American Radium Society, Atlantic City, N. J., June 9-10, 1947.

therapeutic effect. It is because of the frequent neglect of hypertrophied or growing scars that it is necessary to again call attention to these methods of treatment. If the general practitioner, the surgeon and the dermatologist are alert and apply skillfully

likely to be neglected until they have reached a considerable size.

Because of the great tendency of recurrence in the wound after excision and very generally because the second keloid is larger than the first, the surgeon feels almost



FIG. 1. (See page 381 for legend.)

the roentgen rays and radium to scars that are beginning to show hypertrophy, keloids will cease to be a problem in the field of medicine. It is true that in many instances slight wounds (especially in the colored race) lead to the formation of large keloids and often these cause so little inconvenience to the patient that they are

helpless. This helplessness is unnecessary if the surgeon will combine the skillful application of irradiation to the wound after his excision of the keloid. If we make it more generally known that radium and the roentgen rays will prevent these growing scars and generally cause their disappearance, patients will be more likely to seek

assistance. While keloids or hypertrophied scars occur more frequently in the colored race, they are by no means confined to that race and most patients who have come to us for treatment of the condition have been white.

The early work, like most radiation therapy in those days, was done by fractional and indefinite dosage. Even with this in-

cases in which the roentgen rays alone are used. The thicker and older keloids will require more irradiation and more filtration and correspondingly a longer course of treatment. In the more recent cases of hypertrophied scars in which the scar tissue is still young, considerably less treatment is necessary, and less filtration, because it is likely to be more superficial.

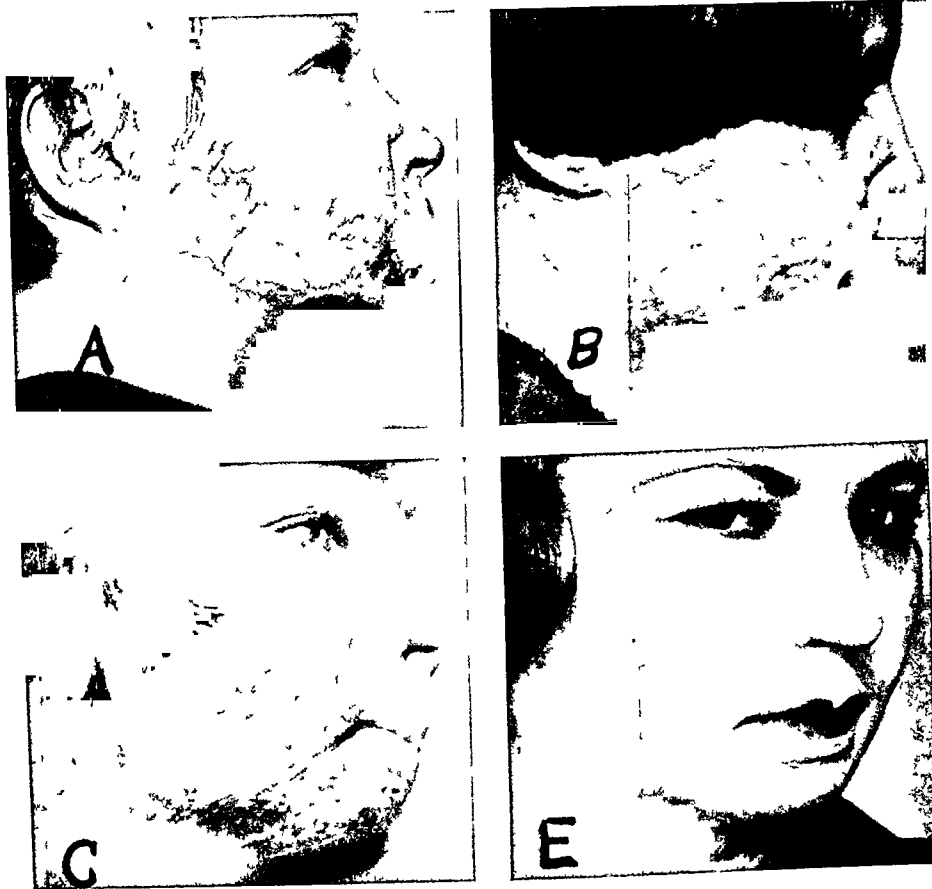


FIG. 2. (See opposite page for legend.)

definite method, some brilliant results have been obtained. Today, with more definite technique, much skill and much keen judgment will still be necessary to obtain the best results for no two cases react in exactly the same way. Generally, the aim should be to produce a progressive atrophy without erythema or destructive effect on the skin or overlying epithelium. The technique will vary considerably with the size or thickness of the keloids, especially in the

Importance of Early Treatment. Nothing could be more important in the discussion of this subject than early and immediate treatment when the physician can observe any tendency to hypertrophy of the scar. It is true that some scars show a little tendency to hypertrophy and later undergo atrophy and need no treatment, but it is better if one does not wait for any such spontaneous recovery. If one can treat keloids within a month or two after the



FIG. 3

FIG. 1, 2 and 3. Case 1. This case is presented in more detail because it has involved more problems and a longer period of treatment than any other patient. At about six years of age, this child was severely burned on the face by the explosion of a coal oil lamp. This burn was followed by an extensive keloid formation involving both sides of the face and chin, and mouth and submental region. She was first referred to one of us (G.E.P.) for roentgen treatment of the keloids on December 4, 1922, at the age of nine years at the Medico-Chirurgical Hospital. *A*, photograph made December 4, 1922. *B*, January 7, 1924, which indicates considerable improvement. *C*, September 20, 1926, which shows more improvement. *D*, February 18, 1929. The treatments in this case were given with fractional doses representing approximately 50 per cent of an erythema dose using monthly intervals, and later at intervals of two months. We used low voltage rays, 125 kv., 5 ma., and 2 mm. Al filtration at 30 cm. distance. After the greater part of the keloid formation had disappeared, we increased this dosage for local smaller areas to an 80 per cent erythema dose at intervals of two or more months, always aiming to keep the irradiation to the minimum. On January 7, 1929, the patient showed no evidence of any keloid formation, but there were loose folds of tissue near the angles of the mouth, which at my request Dr. Robert Ivy removed surgically, and we then controlled the wound during the granulating period by means of localized doses of roentgen rays, using 80 per cent doses of unfiltered radiation.

hypertrophy has been recognized, the keloidal tendency will be arrested usually by irradiation alone, either with the roent-

gen rays or by the use of radium. Either of these agents will produce a satisfactory result, and either can be used according to



FIG. 4. The contraction of the lower lip was not entirely satisfactory and Dr. Robert Ivy advised on November 15, 1933, that this scar tissue be removed surgically and a local skin graft applied, which was done by him. No further treatment was given after that date.

dosage rather than in terms of details of the application. It is taken for granted that every radiologist who is competent to apply treatment to such lesions has at least mastered the knowledge of the erythema dose and the factors that produce it, whether radium or roentgen radiation is used.

The most frequent and the most extensive keloids follow burns. Therefore, the attending surgeon or physician should give special attention to the scars following the healing of extensive burns for, as is well known, such burns when associated with keloids lead to contractures, deformities, and distressing appearances.

Even a very small scar undergoing hypertrophy, for example if it is located on the upper lip or somewhere on a young girl's face, is very important. If treated as soon as this hypertrophy is recognized, one

the convenience of the radiologist. For that reason, we are discussing in erythema



FIG. 5. The final result after all treatment is shown in E (Fig. 1, 2, 3), but the subsequent result on December 5, 1934, five years later, is shown in this illustration.

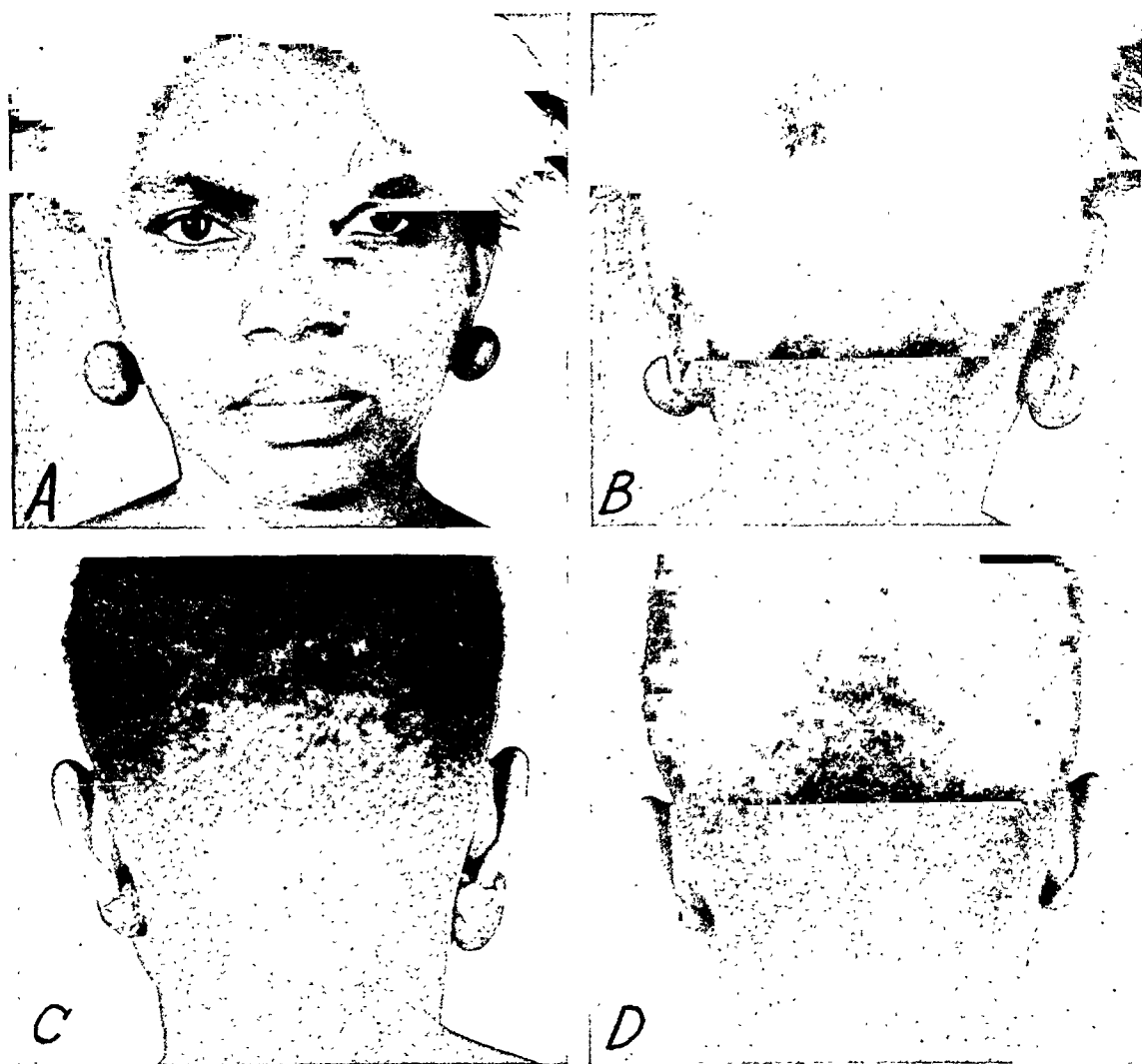


FIG. 6. Case II. Keloids resulting from punctures of the ear lobe for earrings. *A*, anterior view; *B*, posterior view; *C*, after excision, but no postoperative irradiation showing recurrence; *D*, after excision, followed by irradiation, with no recurrence.

or two treatments with 80 to 100 per cent of an erythema dose given to the hypertrophied scar, and confined only to the lesion, will do no harm and generally will arrest the hypertrophy. This treatment is given with superficial or 125 kv. therapy. If one or two doses do not cause this hypertrophy to disappear then it should be repeated. It is our practice in such cases to repeat these treatments one or two months apart. In these small lesions, one can give a large dose and in our observation it has not done any harm at any time, and the results have been perfect. Even ordinary scars are

benefited and made to disappear if treated early by irradiation.

With this thought in mind, when treating even a small lesion on the face we frequently give a postoperative erythema dose preferably about the time that the lesion is healed. We get the impression that this helps to prevent any hyperplasia and even makes the scars less prominent.

In all instances, the larger the area involved the less must be the individual dose and the more frequently it should be applied, especially until the tendency to hypertrophy has been arrested; e. g., in



FIG. 7. Case III. Female, aged forty. Operation Dr. W. L. Rodman. Postoperative treatment February 28, 1916, through the dressings. Wound assumed to be in the upper part of the chest. Microscopical examination showed the lesion to be benign cystic mastitis. Postoperative roentgen therapy was therefore interrupted. Note the keloid formation in the lower half of the wound which received no roentgen treatment.

treating a lesion on the upper lip, 5 mm. in diameter, it is safe to give 80 to 100 per cent of an erythema dose at once, and to repeat in a month or two, but if the lesion is 5 or 10 cm. in diameter, it is unsafe to give such large dosage, and it is better to give a 25 per cent dose at weekly intervals, or a 50 per cent dose at a two week interval.

The Treatment of Older Keloids. The older the keloid the more fibrous tissue has formed, and in all instances where one uses irradiation, it has been observed that the more fibrous tissue there is present in a lesion, the less the response will be of the lesion to irradiation. One must not expect to have large and older keloids disappear from the irradiation without leaving some scarring and atrophy, and perhaps even

some telangiectasis. For that reason, it is best to remove the thickened keloid or reduce it to the level of the skin, and then allow it to granulate under control observation, and control postoperative prophylactic treatment.

These older keloids may be removed with the scalpel, by electrosurgical excision, or by electrodesiccation. Because of the general experience that keloids form, especially after burns, it would seem illogical to attempt to remove the lesion by electrosurgery or to destroy or reduce its size by electrodesiccation, but experience has shown that excellent results can be obtained by this means.

In an older keloid, it seems to us that when the keloid is 2 to 5 mm. in thickness, it is best to destroy it or reduce it to the skin level by electrodesiccation. If it is thicker than this, it seems best to remove it either by electrosurgical excision or by excision with the scalpel. Generally it is impossible to close the wound by sutures. Therefore, one must control the tendency to reformation of the keloid after the excision or destruction by means of irradiation. We have had no experience with excision of keloid followed by skin grafting. The tissue excised by Dr. Ivy (Case 1) had been treated by roentgen irradiation and was no longer keloid.

In a previous discussion of this subject one of us recommended preoperative irradiation as a prophylactic measure. We have no proof of the value of such preoperative irradiation. There is abundant proof of the value of irradiation given immediately after operation. An example of this is shown in a breast (Fig. 7) in which postoperative irradiation was given through the dressings following operation for carcinoma of the breast without knowing the full extent of the excision and it is clearly observed that the hypertrophied scar only took place below the area which received irradiation. This is only an illustrative case. An additional proof of the value of postoperative irradiation in preventing recurrence of the keloid is shown by the fact that in all our

experience we have been able to prevent a recurrence of the keloid by means of post-operative irradiation.

The time for the postoperative irradiation is not definitely established but we know from a very extensive general experience that one can give from 50 to 100 per cent of an erythema dose immediately after an operation, or within a few days and this in no way interferes with the healing of the wound. Therefore, it would seem advisable to give 80 per cent of an erythema dose shortly after the operation. At the end of two weeks the scar should be inspected, and the dosage repeated, or after the operative wound has healed if it has been sutured. If the wound is healing by granulation, treatment should be repeated in about two weeks with a 50 per cent erythema dose. After that time, an inspection should occur in at least two to four weeks, and immediate treatment should be given if there is still any tendency to hypertrophy of the scar. Such a method of treatment will do no harm, and will not interfere with the healing of the wound by granulation tissue.

In general, this postoperative treatment is best given by means of the roentgen rays with 1 or 2 mm. Al filtration depending on the thickness of the lesion, and using 125 kv. This will give sufficient depth value and with less superficial destruction of the epithelium. The distance should be regulated according to the size and thickness of the lesion, varying from 30 cm. distance for a small lesion 1 or 2 cm. in diameter, and 1 or 2 mm. thickness; or 50 cm. for a larger lesion, varying from 5 to 10 cm. or more diameter, and 3 mm. or more thick.

When excising a keloid it is inadvisable to make an extensive excision such as one would do with a malignant tumor. The excision can be confined pretty closely to the actual outline of the tumor or keloid.

In some locations, treatment of keloids is more easily carried out with radium than with roentgen rays, or it may be possible to cross-fire with a combination of roentgen rays and radium. Knox used this method to good advantage in the extensive and deep-

seated keloidal masses developing in the cheeks. Radium was placed in the mouth and roentgen rays were applied to the external surface of the cheek.

Flat radium applicators are usually employed when treating a keloid with radium. In all cases the "soft" beta rays should be eliminated by suitable screening. If the lesion is more than 1 or 2 mm. thick, only gamma rays should be used. In general, the advice given relative to the roentgen treatment of keloid holds for radium when used for the same purpose. A half-strength, glazed, flat element applicator, screened with 0.1 mm. aluminum, may be placed in contact with the keloid for ten, fifteen or twenty minutes, depending on size, age and location. Treatments may be repeated about once monthly. Such applications are suitable for superficial lesions. Gamma rays are employed for thick, hard lesions. The flat application (half-strength) may be screened with 1 mm. brass, and 1 mm. Al and placed in contact with the lesion for eight to twelve hours. This may be given in one treatment or in divided doses of one or two hours daily. Tubular applicators, containing 25 mg. element, or 25 mc. radon, and screened with 1 mm. brass, 0.5 mm. silver and 1 mm. Al or 0.5 mm. Pt and placed at a distance of 1 cm. or 2.5 cm., may be held over each square inch of surface for from two to six hours.

SUMMARY AND CONCLUSIONS

1. Keloids have been treated by irradiation during a period of forty-seven years. The improvements have been made by combining surgery and electrodesiccation since that time.

2. The tendency to hypertrophy of scars should be recognized usually within a month, at which time they are much more sensitive to irradiation and require much less treatment. At this stage, best results are produced.

3. Telangiectasis may be present even before irradiation, but one should aim to avoid telangiectasis which may be due to irradiation.

4. If the keloids or hypertrophied scars are very dense, it is usually best to destroy the lesions to the level of the skin by electrodesiccation or to remove them by the scalpel or electrosurgery. The healing then must be carefully controlled by irradiation, generally by roentgen therapy.

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REFERENCES

1. ALBERS-SCHÖNBERG, and HAHN, R. Die Therapie des Lupus unter der Hautkrankheiten mittels Röntgenstrahlen. *München. med. Wchnschr.*, 1900, 47, 284-325; 363.
2. ALLEN, C. W. Radiotherapy and Phototherapy. Lea & Febiger, Philadelphia, 1904, pp. 244, 288.
3. KNOX, R. Radiography and Radiotherapeutics. Second edition. A. & C. Black, Ltd., London, 1917, p. 562.
4. MORTON, W. J. Artificial fluorescence of living human tissue. *Med. Rec.*, 1903, 64, 215.
5. MORTON, W. J. Primary and recurrent mammary carcinoma treated by the x-ray. *Med. Rec.*, 1903, 63, 845.
6. MORTON, W. J. Some cases treated by the x-ray: facial cancer, carbuncle, cheloid, acne, alopecia areata, sychosis, fibroid tumor, psoriasis, and lupus, *Med. Rec.*, 1903, 64, 121.
7. PFAHLER, G. E. Roentgen rays or radium combined with excision in treatment of keloids. *Arch. Dermat. & Syph.*, 1920, 2, 181.
8. PUSEY, W. A., and CALDWELL, E. W. The Practical Application of the Roentgen Rays in Therapeutics and Diagnosis. Second edition. W. B. Saunders Co., Philadelphia, 1904, p. 647.
9. ULLMANN, C. Der Einfluss des Lichtes auf die gesunde und kranke Haut. *Wien. med. Presse*, 1900, 41, 954.
10. WICKHAM, L., and DEGRAIS, P. Radiumtherapy. Translated by S. E. Dore. Cassell & Co., London, 1910, pp. 160, 172.
11. WILLIAMS. Quoted by Wickham and Degrais.¹⁰
12. MACKEE, G. M., and CIPOLLARO, A. C. X-rays and Radium in the Treatment of Diseases of the Skin. Fourth edition. Lea & Febiger, Philadelphia, 1946, p. 526.



PARTIAL DESTRUCTION OF RAT THYROID BY LARGE DOSES OF RADIO-IODINE

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THE scientific literature contains little evidence of the much publicized destruction of the thyroid gland by large doses of radioactive iodine. Relief of hyperthyroidism was obtained by Hertz and Roberts in Boston using from 5 to 25 millicuries of a mixture of I^{131} and I^{131} in human patients. The radiation dose delivered to the thyroid ranged from about 500 to 2,500 equivalent roentgens per gram of thyroid tissue.¹ Chapman and Evans² working with doses ranging between 14 and 79 millicuries of the same isotopes obtained clearcut clinical evidence that these amounts reduced basal metabolism and relieved other symptoms of hyperthyroidism. Histological studies were carried out by biopsy in 2 patients, and revealed some fibrosis of the thyroid several months after the radio-iodine treatment. Seidlin, Marinelli and Oshry³ used radio-iodine to treat a patient with metastasizing adenocarcinoma of the thyroid over a period of three years: the patient received a total of more than 235 millicuries in the form of I^{131} and I^{131} , which supplied an estimated radiation dose of about 40,000 equivalent roentgens to his tumors. The patient was clinically improved and there was roentgenographic evidence of regression of his disease. It has been assumed by these various authors that the thyroid was destroyed by the radio-element, but there is little histological evidence of this fact.

In unpublished work, Leblond and Curtis⁴ found that injection of radio-iodine I^{131} into groups of 6 rats in single doses of 0.1, 1, 10 and 30 microcuries respectively caused little or no destruction of the thyroid, as evidenced by data based on weight gain and heart rate and by histological studies. In the group receiving 30 microcuries, there were a few damaged follicles, while numerous mitoses and a general increase in cell

size indicated the presence of a compensatory hypertrophy of the thyroid. The doses in this experiment had been calculated on the basis of those used in man by the Boston group. The small extent of the destruction suggested the possibility that the rat thyroid was more resistant than the human. The feeding of the animals, however, on a commercial, iodine-rich diet may have interfered with the entry of iodine in the thyroid.

In order to avoid these difficulties, it was decided to work with a small group of animals fed on a diet of low iodine content and to administer relatively massive doses of radio-iodine. A clearcut, though only partial destruction of the thyroid gland was thus obtained and histologically demonstrated.

METHODS

Five female albino rats weighing between 140 and 180 grams were kept on a low iodine diet for ten weeks prior to the experiment. This diet (Remington No. 342)⁵ was composed of: corn meal, 78 per cent; wheat gluten, 18 per cent; dried pig liver, 2 per cent; calcium carbonate, 1 per cent; and sodium chloride, 1 per cent. This diet was shown to produce some hypertrophy of the thyroid and increase the uptake of radio-iodine by this gland in the rat.⁶ More recently, in unpublished work,⁷ it was found that the thyroids of rats kept on this diet contained 11 per cent of a carrier-free dose of radio-iodine one hour after injection, and 53 per cent, twenty-four hours after injection; thyroids of rats on the same diet which had received drinking water containing iodine in amounts of 2 micrograms per cc. had taken up only 2 per cent of the injected dose, one hour after injection, and 9 per cent, twenty-four hours after injection.

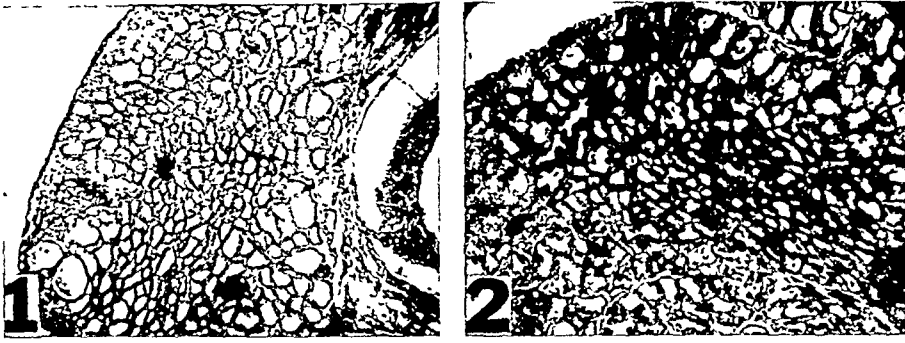


FIG. 1. Thyroid of a control animal showing normal arrangement of fairly evenly sized follicles. Hematoxylin-eosin stain. $\times 40$.

FIG. 2. Thyroid of another control animal showing a more pronounced hyperplasia as indicated by thicker epithelium and smaller colloid accumulations. Hematoxylin-eosin stain. $\times 40$.

FIG. 3. Thyroid of injected animal (A) showing central destruction with a few remaining peripheral acini containing colloid. Hematoxylin-eosin stain. $\times 40$.

FIG. 4. Thyroid of injected animal (B), showing similar results as in Figure 3, except that more normal colloid is visible. A slight fibrous infiltration is apparent. Hematoxylin-eosin stain. $\times 40$.

FIG. 5. Autograph (animal A) showing areas of storage of radio-iodine in peripheral acini. Relatively little

tion. It was expected, therefore, that this diet would favor the retention of a large percentage of the injected dose in the thyroid and thus facilitate the destruction of thyroid tissue. Three animals were used as controls and two animals, A and B, were injected with radio-iodine.

The radio-iodine prepared by deuteron bombardment of tellurium was extracted without addition of carrier iodide. Only the eight day isotope I^{131} was injected. (It was shown that there was no twelve-hour isotope at the time of injection by following the rate of decay of the radioactivity on the Geiger counter.) The animals received a single intraperitoneal injection of I^{131} as sodium iodide. Animal A received approximately 78.5 microcuries and animal B, 60.8 microcuries. The animals were sacrificed exactly six days after the injection of radio-iodine.

The basal metabolic rate of the rats was followed for three days before, and six days after the injection of radio-iodine, by measuring their oxygen consumption for a period of twenty minutes under conditions of rest. At the same time the heart rates were estimated from electrocardiograms taken on each animal.

At autopsy, the left lobes were used for histological and autographic studies. The right lobes of the thyroids were placed in 2 cc. of 2 N sodium hydroxide and heated until digested. Each solution was then dried on a 40 mm. watch glass for three hours at 70° C. The radioactivity was determined by placing the watch glass under the window of a bell-shaped beta-ray Geiger counting tube. The concentration of radio-iodine was estimated by comparison with a standard solution prepared in the same manner.

The histology of the thyroids was examined on sections which included the trachea

and adjacent structures, using hematoxylin-eosin and Masson's trichrome stains. The correlation between histological picture and location of the radio-element was studied on radioactive autographs prepared by a method in which the slides bearing the stained sections were dipped into 1 per cent celloidin, dried overnight and coated in the dark room with melted photographic emulsion.⁸ The slides were then set aside for exposure in boxes wrapped in black paper. After an exposure period of one to six days, they were developed and fixed according to the usual photographic procedure. On such autographs, black silver granules form in the emulsion coating over the sites of radioactivity in the section (Fig. 14).

RESULTS

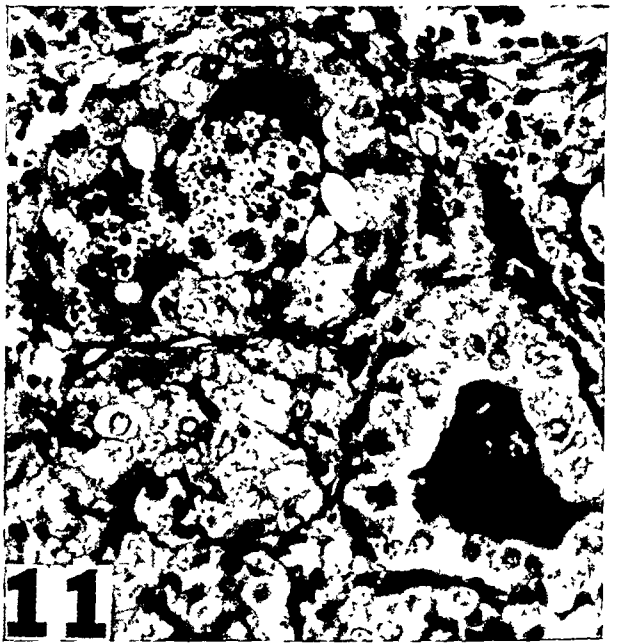
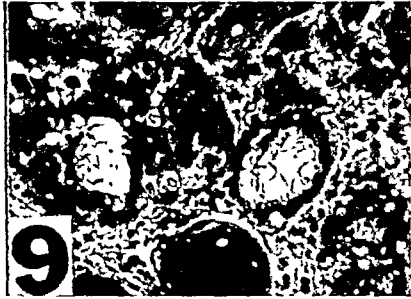
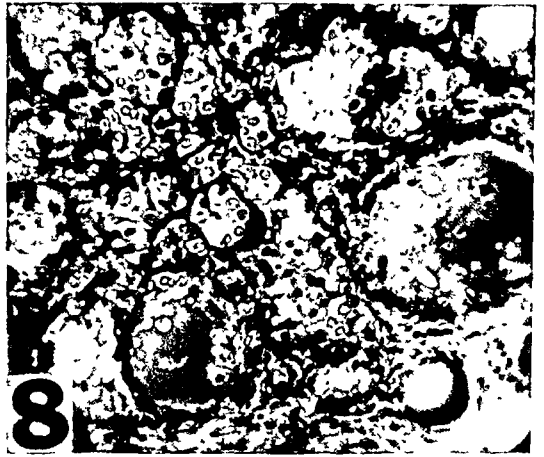
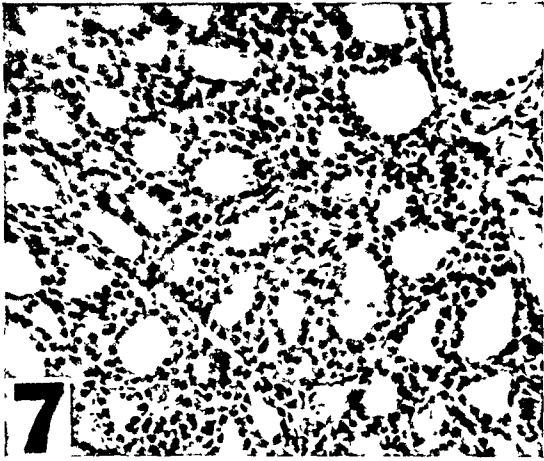
The oxygen consumption of animal A decreased from 63 to 47 cc., and that of animal B, from 55 to 54 cc. of oxygen per hour per square centimeter of body surface. The heart rate of animal A decreased from 468 to 413 beats per minute and that of animal B, from 421 to 339 beats per minute. The values were too few to give an accurate measure of the decrease in thyroid function and should only be considered as indicating a trend in this direction.

Histological studies of the control groups showed active thyroids (Fig. 1). Under high power, the follicles appeared well filled with colloid (Fig. 7). One of the control glands presented a picture of moderate, diffuse hyperplasia (Fig. 2).

The contrast between the thyroids of the controls (Fig. 1 and 2) and those of the treated animals (Fig. 3, 4 and 14) was striking. Instead of the normal picture of regularly arranged follicles, the treated thyroids showed a transformation of most of the follicles into solid cell groups with

radio-iodine is localized in the central area of the gland. Hematoxylin-eosin stain. $\times 40$. (The autograph was exposed for six days.)

FIG. 6. Autograph (animal B) of a section made nearer the lower pole of the gland than in Figure 4, showing the predominance of radio-iodine deposition in peripheral areas. Masson stain. $\times 40$. (The autograph was exposed for one day.)



✓ Figs. 7-13. See opposite page for description.

disappearance of the colloid, especially in the central region of the glands (Fig. 3). In these solid cell groups, the epithelial cells displayed a lack of regular arrangement (Fig. 8, top left). Some of the cells showed cloudy swelling with nuclei which varied in size and were in some cases pyknotic. In others the cytoplasm was transformed into small colloid globules. Some of the cells undergoing this colloid transformation were ejected into the lumen of the follicles (Fig. 11). There was a slight increase in the amount of interstitial fibrous tissue accompanied by scattered lymphocytic infiltration (Fig. 9). Edema was pronounced, especially in animal A (Fig. 3, top center). The peripheral follicles were more normal in appearance, and some of these retained the smooth looking colloid characteristic of normal follicles (Fig. 4). In many follicles, however, the colloid showed a transformation into acidophilic filaments (Fig. 9). These acidophilic filaments were often loosely scattered throughout a follicular lumen retaining some smooth colloid. In some follicles, more numerous acidophilic filaments were found without any recognizable colloid between them. Finally, tightly packed filaments were present in a few follicles, the walls of which had collapsed on the reddish clump of filaments.

The follicles in the thyroid isthmus appeared undamaged and larger than in control animals, the increase in the size of the cells suggesting an intense stimulation.

Tissues surrounding the thyroid showed

evidence of radiation injury. The tracheal epithelium adjacent to the gland showed a change from its normal arrangement with columnar pseudo-stratified ciliated epithelium (Fig. 12) to an irregular structure with pyknotic nuclei, disappearance of cilia, cloudy swelling, and subepithelial lymphocytic infiltration (Fig. 13). In areas far removed from the gland, the epithelium was of normal appearance (Fig. 12).^{*} The parathyroid gland showed a few pyknotic nuclei in the areas in closest apposition to thyroid tissue (Fig. 10, arrows). Neighboring cartilage and muscle tissue were not affected.

The amount of radio-iodine present in the glands at the time of autopsy was determined on the Geiger counter. In the case of animal A, 0.67 per cent of the injected dose was present in the right lobe, and therefore it was assumed that the whole gland must have contained twice that amount, namely 1.35 per cent of the injected dose. Similarly, the thyroid of animal B was estimated to contain 15.20 per cent of the injected dose.

The localization of radio-iodine inside the gland was demonstrated by the autographic method. The accumulations of dark granules indicative of the presence of radio-iodine were found chiefly in the peripheral

^{*} The zones of the trachea which were affected by the radio-iodine were located at a distance from thyroid tissue inferior to 1 mm. In man, the distance between thyroid tissue and tracheal epithelium is more than 1 mm., and therefore the danger of damage to the tracheal epithelium with doses of radioactivity similar to those used here is more remote.

FIG. 7. Thyroid of control animal. Hematoxylin-eosin stain. $\times 168$.

FIG. 8. Thyroid of injected animal (A) showing replacement of acinar structure by clumps of epithelial cells (upper left quadrant). Two clearly visible follicles are fairly normal, except for a few damaged cells which dropped into the colloid. Masson stain. $\times 168$.

FIG. 9. Thyroid of injected animal (B) showing fibrillation of the colloid in two follicles. Some increase of fibrous tissue and wandering cells may be seen. Masson stain. $\times 168$.

FIG. 10. Showing parathyroid tissue near the edge of thyroid in an injected animal (A). Arrows indicate pyknotic nuclei. Masson stain. $\times 168$.

FIG. 11. Showing degeneration of acinar epithelium with formation of colloid globules in animal A. Masson stain. $\times 350$.

FIG. 12. Tracheal epithelium in posterior part of trachea, showing normal structure. Hematoxylin-eosin stain. $\times 168$.

FIG. 13. Tracheal epithelium adjacent to thyroid tissue showing pronounced lesions with some lymphocytic infiltration. Hematoxylin-eosin stain. $\times 168$.

areas of the gland (Fig. 5, 6 and 14). Microscopic study showed them to be present only in the colloid of the more normal appearing follicles. Those showing filamentous colloid did not contain radio-iodine. Similarly, little or no radio-iodine was present in the central areas of the gland where the follicles had been replaced by solid cell cords (Fig. 5).

DISCUSSION

That the large doses of radio-iodine damaged the thyroid was suggested by the decline in oxygen consumption and heart rate and was definitely proved by the histologically visible lesions.

The histological appearance combined some evidence of stimulation with intense signs of destruction. The enlarged cells in the follicles in the isthmus may probably be attributed to a stimulation by an excessive release of thyrotrophic hormone resulting from the interference with thyroid secretion. Possibly the colloid degeneration of many cells throughout the glands may also be the result of this stimulation, since such degeneration is a common occurrence in our experience in rats treated with thyrotrophic hormone. The ejection into the follicular lumen of cells undergoing colloid degeneration may also be seen in activated thyroids.

The symptoms of destruction were maximal in the central areas of the gland where the follicles were replaced by solid groups of irregularly arranged and often damaged cells. The more pronounced destruction of the central part of the thyroid was probably a consequence of the more rapid entry and turnover of iodine which takes place in this part of the gland as could be shown with small doses of radio-iodine.⁷ In the peripheral areas of the gland, more normal looking follicles than in the center may be seen, but even some of these showed signs of damage. An unusual pattern of destruction could be observed in those follicles. At first, acidophilic filaments appeared in the colloid. These filaments increased in number as the normal smooth looking colloid decreased in

amount. Finally, the follicular lumen was packed with the filaments and the walls collapsed, this apparently being the last step before disappearance of the lumen contents and disorganization of the epithelium.

The damaged thyroid glands had also lost to some extent their ability to fix radio-iodine. Indeed, animal A, which histologically showed a greater number of damaged follicles than animal B (Fig. 3 and 5) had a thyroid which contained only 1.35 per cent of the injected dose, while the gland of animal B retained 15.10 per cent of it. This observation indicated that the iodine uptake may be used as an index of the vitality of the gland as suggested by Seidlin *et al.*³

The autographic results confirmed the presence of more radio-iodine in the thyroid of animal B than in that of animal A and even supplied some explanation of this difference. Most of the follicles in A had been either completely destroyed or showed a filamentous degeneration of the colloid; such destroyed or degenerated follicles did not retain radio-iodine. On the other hand, the thyroid of animal B contained many more normal-looking follicles than that of animal A; and, as a consequence, many more of the follicles had retained radio-iodine.

The more prolonged retention of radio-iodine in the thyroid of animal B—given a smaller dose than animal A—might result in the long run in a destruction equal to that found in animal A—given the larger dose. The retention of radio-iodine by the follicles until they are seriously damaged, as revealed by the autographs, should eventually result in the destruction of all the gland. This behavior should even cancel to some extent the differences in the effect of various doses, since the longer retention of small doses makes them effective for longer periods of time. Practically, however, the destructive action of small doses of I^{131} is limited by the comparatively short half life of this isotope (eight days).

A rough calculation of the amount of radiation delivered to the thyroids of the

animals over the six day period of the experiment showed that the relatively enormous dose of 20,000 equivalent roentgens per gram of thyroid tissue had been effective in these glands.¹ This large dose explains why considerable lesions were produced in six days, despite the well

single doses of 78.5 and 60.8 microcuries of carrier-free radio-iodine I^{131} respectively. Thyroid function was estimated by basal metabolic rate and heart rate determination. After six days the animals were sacrificed and the thyroid histology studied by means of stained sections and autographs. It was

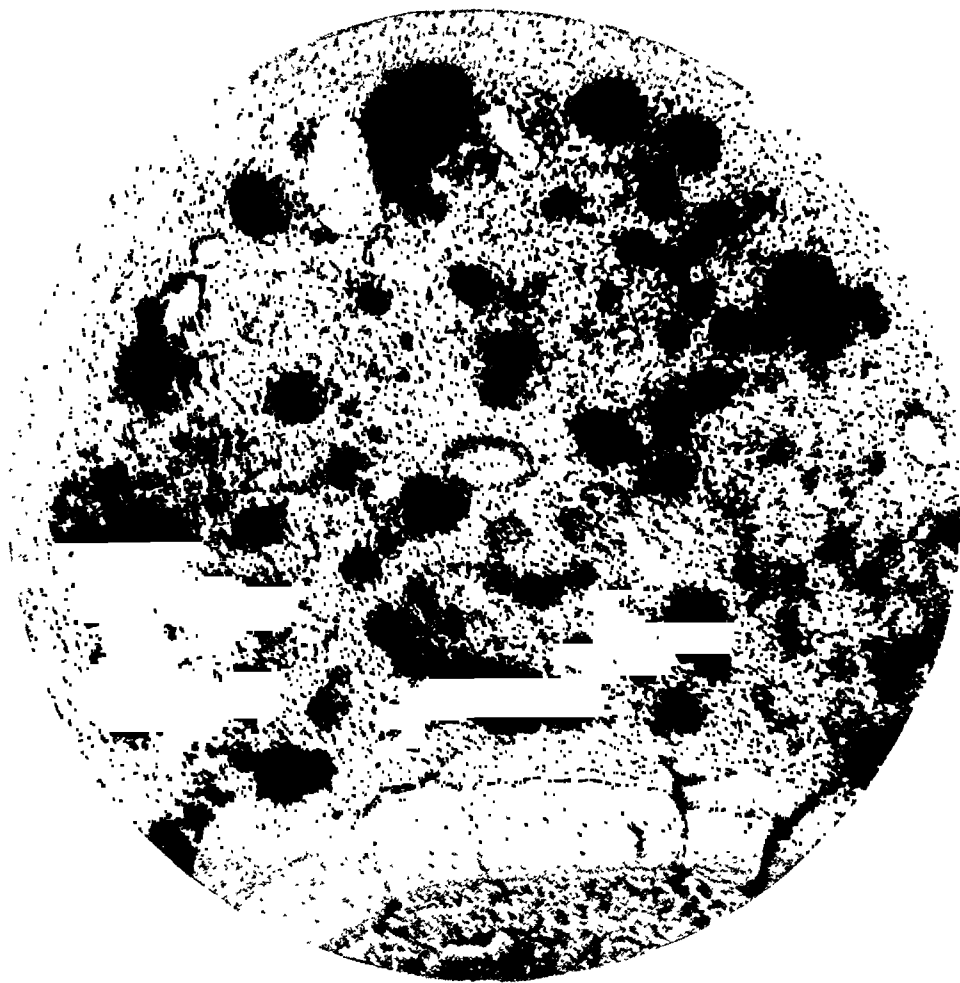


FIG. 14. Autograph of an injected animal (B). The green-staining connective tissue capsule of the gland is visible on the outside. Slight fibrous infiltration (green) and edema are apparent inside the gland. The black masses are the photomicrographic reactions corresponding to the follicles which have retained the ability to take up radio-iodine. The reddish masses correspond to the solid cell cords resulting from the destruction of most follicles by radio-iodine. A few blood vessels are also visible. Masson stain. $\times 75$.

known resistance of thyroid tissue to radiation¹¹⁻¹⁵, especially in the rat.⁴

SUMMARY

(1) Two adult female albino rats, kept on a low iodine diet for ten weeks, were given

calculated that about 20,000 equivalent roentgens were received by the thyroid glands of the animals.

(2) Such doses of radio-iodine impair the function of the thyroid, as suggested by some decrease in oxygen consumption and

heart rate of the animals.

(3) The histological study of the thyroid glands of these animals shows destructive lesions of the follicles especially in the central areas of the gland (Fig. 3, 9 and 11). Many peripheral follicles retain a normal appearance.

(4) Autographic studies show that only the normal looking follicles with smooth colloid have the ability to retain radio-iodine (Fig. 14).

(5) Although the thyroid gland is resistant to the action of radiations, it can be destroyed by the isotope I^{131} of iodine. The damage is favored by the retention of radio-iodine inside the thyroid follicles until they are markedly damaged.

ACKNOWLEDGMENTS

This work was completed with the help of a grant from the National Cancer Institute of Canada.

The radio-iodine was kindly supplied by Dr. A. L. Hughes and Dr. F. N. D. Kurie as tellurium bombarded in their cyclotron at Washington University, St. Louis, Mo. The extraction was carried out by Dr. S. Albert and Dr. J. Gross in this Department. The measurements of oxygen consumption and heart rate were carried out by Mr. B. Grad. The wheat gluten used in the iodine-free diet was obtained from Ogilvie Flour Mills, Montreal, through the courtesy of Dr. W. Parker.

ADDENDUM

The amount of radiation affecting the thyroid was dependent firstly on the number of injected atoms undergoing disintegration during the six days of the experiment and secondly on the fraction of this injected dose present in the gland—a variable value which for the sake of argument was taken equal to D on the average.

If one neglects the gamma radiation of I^{131} which may be presumed to have negligible efficacy in the small rat thyroid and consider the beta radiation, the problem may be examined in its general form as follows. Let

N_0 , be the number of isotopic atoms in the injected dose at time 0 (time of injection),

N_t , the number of these isotopic atoms remaining at time t ,

i_t , the number of atoms disintegrating per second at time t ,

T , the half-life of the radio-element (equal to eight days in the case of I^{131}); the *average life* of a radio-element is equal to

$$\frac{T}{0.695}$$

days or

$$\frac{T \times 86400}{0.695}$$

seconds,

p , the radioactivity constant, that is to say the fraction of the number of atoms which disintegrates per second (p is a constant, equal to the reciprocal of the average life),

I , the total number of atoms disintegrating during the time interval from 0 to t .

The basic radioactivity formula supplies the number of isotopic atoms remaining at time t , namely

$$N_t = N_0 e^{-pt}.$$

The number of atoms disintegrating per unit time at any time t , that is to say pN_t , will then be

$$i_t = -pN_t = -pN_0 e^{-pt}.$$

Therefore the total number of atoms disintegrating and thus effective in the tissues, between time 0 and t is

$$I = \int_0^t -pN_0 e^{-pt} dt = \frac{-pN_0 e^{-pt}}{p} + C$$

where C , the constant of integration, may be calculated by making $t=0$. Since in these conditions $I=0$, C is found to equal N_0 . Hence

$$I = -N_0 e^{-pt} + N_0 = N_0(1 - e^{-pt}).$$

The value of N_0 may be calculated in the case of animal A which received 78.5 microcuries of I^{131} , that is to say a dose producing $78.5 \times 3.7 \times 10^4$ disintegrations per second at the time of injection. The number of isotopic atoms injected was equal to the total number of disintegrations due to take place during the life of the radio-element, namely:

$$\begin{aligned} N_0 &= (78.5 \times 3.7 \times 10^4) \times \left(\frac{T \times 86400}{0.695} \right) \\ &= (78.5 \times 3.7 \times 10^4) \times \left(\frac{8 \times 86400}{0.695} \right) \\ &= 2.88 \times 10^{12} \end{aligned}$$

This value makes it possible to calculate the total number of atoms disintegrating during the six days after injection:

$$\begin{aligned} I &= 2.88 \times 10^{12} \left(1 - e^{-\frac{0.695 \times 6 \times 86400}{T \times 86400}} \right) \\ &= 1.19 \times 10^{12} \end{aligned}$$

The proportion of this number of atoms disintegrating in the thyroid was

$$\frac{D}{100} \times (1.19 \times 10^{12}) = D \times 1.19 \times 10^{10}$$

Since the average energy of the beta particles of I^{131} is (2.5×10^5) electron volts (Marinelli *et al.*⁹), the energy produced in the gland was:

$(D \times 1.19 \times 10^{10}) \times (2.5 \times 10^5) = D \times 2.44 \times 10^{15}$ electron volts.

On the other hand, 1 roentgen in 1 gram produces (5.22×10^{13}) electron volts (Marinelli¹⁰), and, therefore, the thyroid of animal A—weighing 0.02 gm.—received:

$$\frac{(D \times 2.44 \times 10^{15})}{(5.22 \times 10^{13}) \times 0.02} = D \times 2,340 \text{ equivalent roentgens per gram.}$$

Similar calculations for animal B showed that this animal received $D \times 1,800$ equivalent roentgens per gram of thyroid tissue.

Unfortunately, it was most difficult to obtain an accurate value for D . Indeed, D could not be computed from data obtained with non-destructive doses of radio-iodine in this and other laboratories, since the ability of the thyroid to take up iodine was impaired by the large dose of radio-iodine as shown by the small amount present in the thyroid of animal A. Another complicating factor was the loss of radiation due to the extension of the I^{131} beta rays range beyond the thyroid, as shown by lesions in parathyroid and trachea. As a rough approximation attempting to take these various factors in consideration, D was made equal to 10. The calculated dose of radiation thus became for animal A 23,400, and, for animal B 18,000 equivalent roentgens per gram of thyroid tissue.

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REFERENCES

1. HERTZ, S., and ROBERTS, A. Radioactive iodine in thyroid physiology. *J.A.M.A.* 1946, 131, 81-85.
2. CHAPMAN, E. M., and EVANS, R. D. Radioactive iodine in hyperthyroidism. *J.A.M.A.*, 1946, 131, 86-91.
3. SEIDLIN, S. M., MARINELLI, L. D., and OSHRY,

S. E. Radioactive iodine therapy effect on functioning metastases of adenocarcinoma of the thyroid. *J.A.M.A.*, 1946, 132, 838-847.

4. LEBLOND, C. P., and CURTIS, G. M. Unpublished data, 1944.
5. REMINGTON, R. E. Improved growth in rats on iodine deficient diets. *J. Nutrition*, 1937, 13, 223-233.
6. LEBLOND, C. P., and MANN, W. Fixation of iodine by thyroids of rats given diets deficient in iodine. *Proc. Soc. Exper. Biol. & Med.*, 1942, 49, 102-105.
7. LEBLOND, C. P., FINDLAY, D., and GROSS J., Unpublished results, 1947.
8. LEBLOND, C. P., PERCIVAL, W. L., and GROSS, J. A method for the autographic localization of radio-iodine in stained sections of thyroid gland coated with a photographic emulsion. *Proc. Soc. Exper. Biol. & Med.*, 1948, 67, 74-76.
9. MARINELLI, L. D., BRINCKERHOFF, R. F., and HINE, G. J. Average energy of beta-rays emitted by radioactive isotopes. *Rev. Modern Physics*, 1947, 19, 25-28.
10. MARINELLI, L. D. Dosage determinations with radioactive isotopes. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 210-216.
11. WARREN, S. Effects of radiation on normal tissues. *Arch. Path.*, 1943, 35, 304.
12. BOWER, J. O., and CLARK, J. H. The resistance of the thyroid gland to the action of radium rays; results of experimental implantation of radium needles in the thyroid of dogs. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1923, 10, 632-643.
13. WALTERS, O. M., ANSON, B. J., and IVY, A. C. The effect of x-rays on the thyroid and parathyroid glands. *Radiology*, 1931, 16, 52-58.
14. ECKERT, C. T., PROBSTEN, J. G., and GALINSON, S. Radiation of the thyroid; experimental study in radiosensitivity of the thyroid, *Radiology*, 1937, 29, 40-44.
15. GARLAND, L. H., CUTTING, W. C., ROBSON, G. B., and NEWMAN, W. W. Effects of roentgen irradiation on experimental hyperthyroidism. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1941, 45, 692-695.



RADIOAUTOGRAPHY

SOME PHYSICAL AND RADIOBIOLOGICAL ASPECTS OF THE TECHNIQUE AS APPLIED TO THIN SPECIMENS*†

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1. THE EXPOSURE TIME

THE determination of the adequate time of exposure in radioautographic techniques is fraught with many uncertainties. As a rule, adequate images are sought by exposing the photographic material to serial tissue sections for progressively longer periods of time. With this procedure the correct time is estimated empirically by observing the results obtained with several suboptimal exposures. This method is tedious and time consuming and yet, by disregarding it, one may be faced with total failure.

While empiricism cannot be excluded in toto, it is possible to reduce both work and uncertainty to a minimum by the application of the elementary laws of radioactivity. Since the reciprocity law (Bunsen-Roscoe) holds for ordinary beta and gamma rays⁵ one may expect a certain degree of blackening, D , upon exposure of a certain plate to a given quantity of radiation, L , impinging on a unit surface, irrespective of the time necessary to deliver it. The quantity of radiation, L , is the result of radioactive decay of an element from an amount A_0 per unit surface at the beginning of the exposure t to an amount A_t at the end of it. We may write

$$L = A_0 - A_t.$$

Since

$$A_t = A_0 e^{-\lambda t}$$

($\lambda = \frac{0.693}{T}$, is the decay constant and T

the half-life of the element) it follows that:

$$L = A_0(1 - e^{-\lambda t}).$$

Solving for t

$$t = \frac{T}{0.693} \log \frac{A_0}{A_0 - L}. \quad (1)$$

This equation gives the required exposure time t in terms of the half-life of the element, the initial activity A_0 per unit surface of the tissue section and the activity L , which the section must lose, in order that a given blackening be produced. Once L has been determined as a constant for a given isotope, emulsion and conditions of development, this equation will allow the determination of the exposure time for any tissue section containing the isotope in any measurable activity, irrespective of the type of radiation emitted or the density of blackening corresponding to L . In this presentation, A_0 is expressed in terms of microcuries per cm.², L in microcuries destroyed per cm.² ($\mu\text{cd}/\text{cm}^2$).*

In this study, A_0 was determined by comparison with a known quantity of radioelement, by means of standard procedures. Thus Figure 1 shows a lead-shielded Geiger-Müller counter, where the activities of the tissue sections were measured. The tube is mounted horizontally and the shield is provided with a drawer as shown in (a). The drawer contains a depression, into which a block of wood is fitted. The block has a groove into which glass slides

* A microcurie is the amount of isotope disintegrating at the rate of 3.7×10^4 atoms per second.

* Presented at the Twenty-ninth Annual Meeting, American Radium Society, Atlantic City, N. J., June 9-10, 1947.
† This paper is based on work done under contract N6 O.R.I.-99, Task Order No. 1, with the Office of Naval Research.

supporting the tissue sections are mounted in reproducible position. When completely assembled, as shown in (b) and (c), the

In order to determine L for equation (1), filter paper (Munktell's number 00) impregnated with radioactive isotopes was

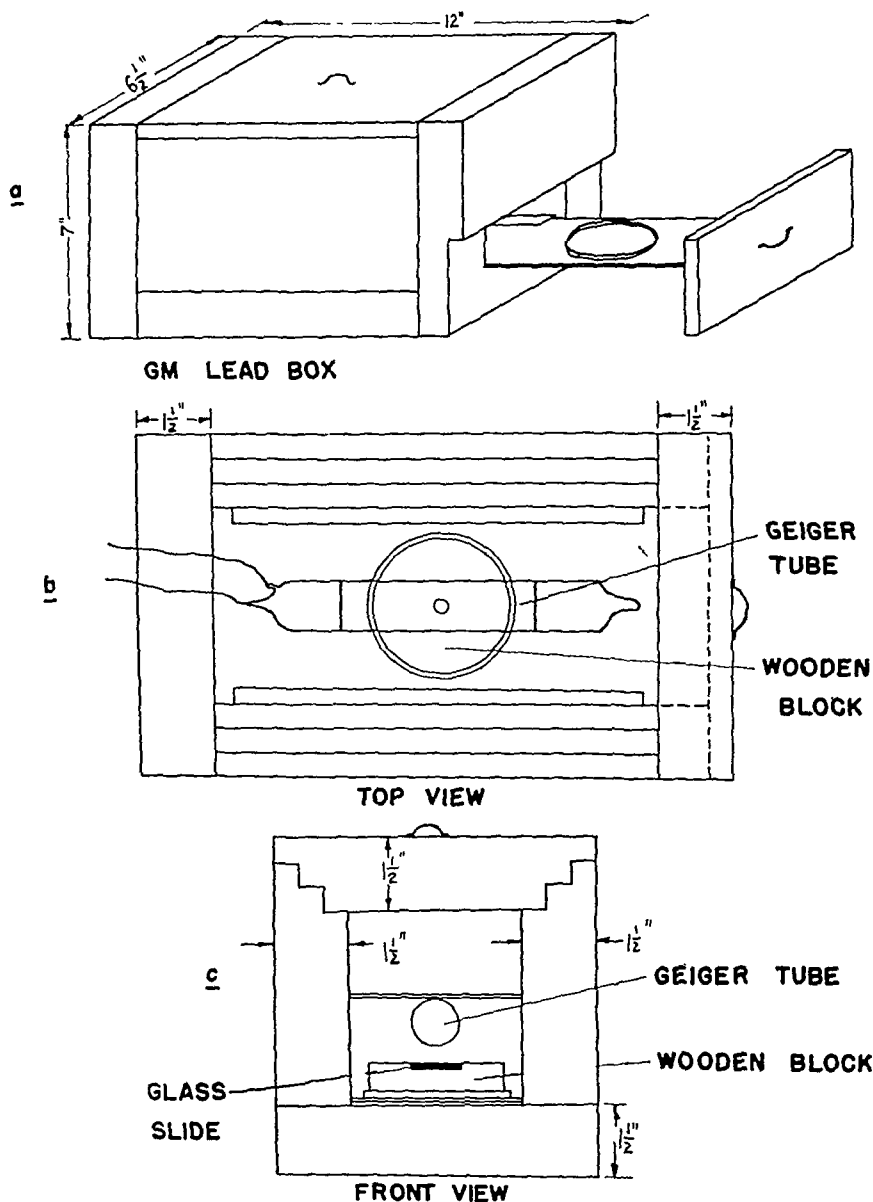


FIG. 1. Views of the apparatus used to measure the radioactivity of tissue sections.

tissue section is directly underneath the sensitive volume of the counter, at a distance of about 1 inch. By drying a small, known volume of a solution containing a known activity, on a glass slide similarly placed, one can calibrate the tube in terms of counts/minute/microcurie* and obtain A_0 for the tissue section in question.

used. Large pieces were dipped into solutions of I^{131} or P^{32} , allowed to dry, trimmed at the edges and then cut into 1 centimeter

* The I^{131} calibration was based on its gamma-ray output (2.65 roentgens per millicurie-hour at 1 cm.); the P^{32} calibration was based on the average value of an intercheck carried out in April, 1946, by the National Bureau of Standards, University of California (Berkeley), Massachusetts Institute of Technology, and the United States Atomic Energy Commission (Oak Ridge).

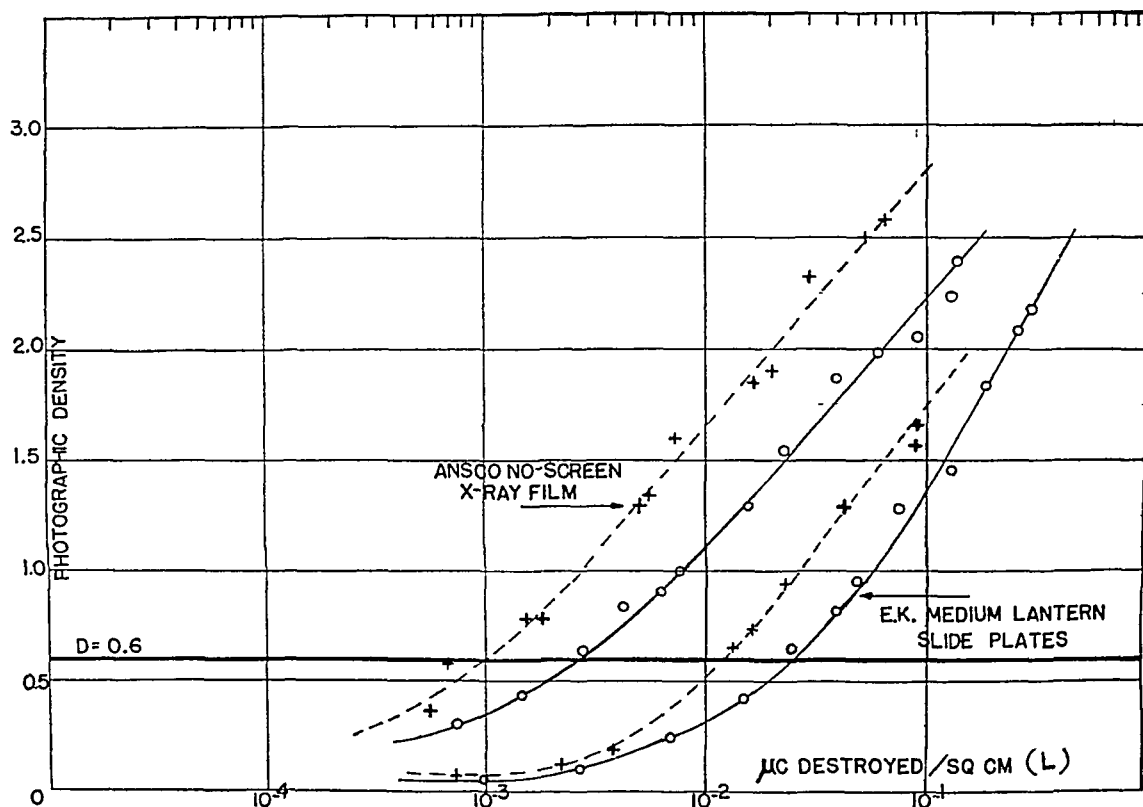


FIG. 2. Photographic density as a function of microcuries destroyed per sq. cm., for 2 types of emulsion
Broken lines— P^{32} ; solid lines— I^{131} .

squares. These were placed on glass slides and their activities measured. After this, they were placed on Eastman Kodak medium lantern slide plates or Ansco no-screen x-ray films, each square being held down with a brass weight, placed on top of the glass. The squares were exposed for different lengths of time (one hour to seven days). After exposure, the plates and films were developed and the photographic densities were measured with a photoelectric

densitometer. The relationship between densities and $\mu\text{cd}/\text{cm}^2$ for all 4 cases is shown in Figure 2. The curves to the right refer to I^{131} and P^{32} on the lantern slide plates and those to the left refer to the same isotopes on roentgen film. Table I shows the values of L corresponding to a density of 0.6 which was chosen arbitrarily as a standard. It is seen that, for both isotopes, the sensitivity of the roentgen film is about 10 times that of the lantern slide plates.

Since the beta-ray spectra of these elements are continuous and therefore include rays of low penetrating power, it was thought advisable to ascertain whether the absorption in the filter paper ($6.2 \text{ mg}/\text{cm}^2$) was appreciable. This was done by exposing the photographic emulsion to two and three superimposed layers of filter paper containing approximately the same quantity of isotope per unit surface. It was found that the *photographic densities* produced by

TABLE I
VALUES OF L IN $\mu\text{CD}/\text{CM}^2$ FOR $D=0.6$

Isotope	Emulsion	L
I^{131}	Eastman Kodak medium lantern slides	0.025
	Ansco No-Screen x-ray film	0.0027
P^{32}	Eastman Kodak medium lantern slides	0.0120
	Ansco No-Screen x-ray film	0.0010

the double and triple layers were the same densities that would have been produced (as shown by the curves of Figure 2) had these multiple activities been confined to only one layer of paper. This showed that

limit of experimental error. It was concluded, therefore, that the filter paper procedure may be safely used to determine L for tissue sections of a thickness at least as great as 6.2 mg/cm.^2 ($\sim 62 \mu$) when the

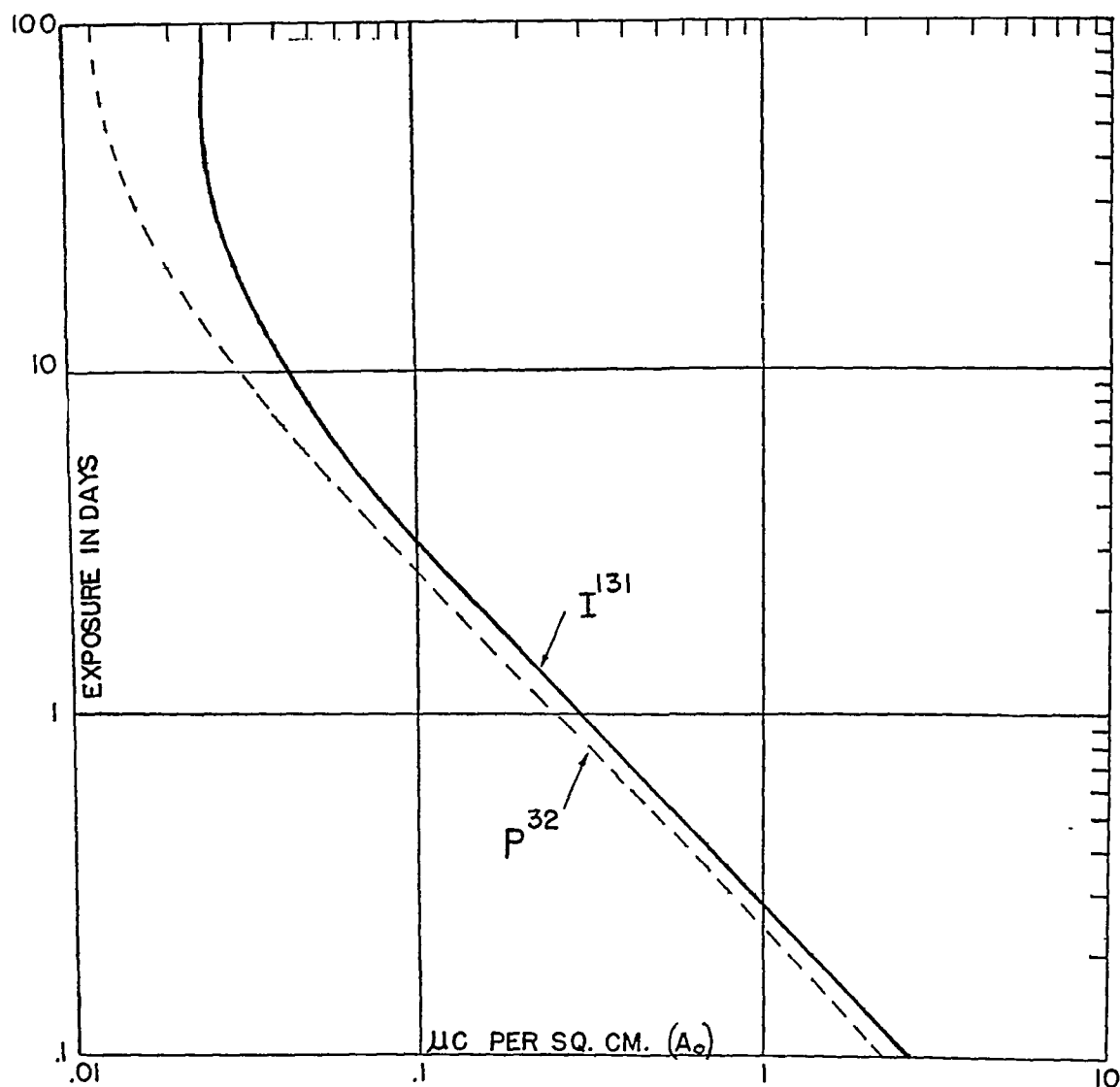


FIG. 3. Exposure time as a function of initial activity, for Eastman Kodak medium lantern slide plates and photographic density of 0.6.

practically all the radiations reached the emulsion. This was confirmed by exposing, for the same lengths of time, one slip of paper and a set of two slips, each of half the activity per cm.^2 of the one, the two being superimposed. In this case, the density produced by the set was equal to the density produced by the one slip, within the

isotopes in question are I^{131} or P^{32} . One could not expect this to apply however, to elements such as C^{14} and S^{35} , whose beta rays have very much less energy.

By substituting the values of L in equation (1) a relationship between the exposure time t and the initial activity A_0 is obtained. In Figure 3 this was done for I^{131} and P^{32}

on medium lantern slide plates and $D=0.6$. The required value of the exposure time can be read directly on the ordinate scale once the activity of the tissue section in $\mu\text{C}/\text{cm}^2$ is known. Figure 4 shows similar curves for the no-screen x-ray film.

graph is made. The latter, however, need not be of optimal exposure and usually can be guessed by visual inspection of the section. In the case of tissue sections cut from the thyroid gland, the factor of uncertainty due to inhomogeneous distribu-

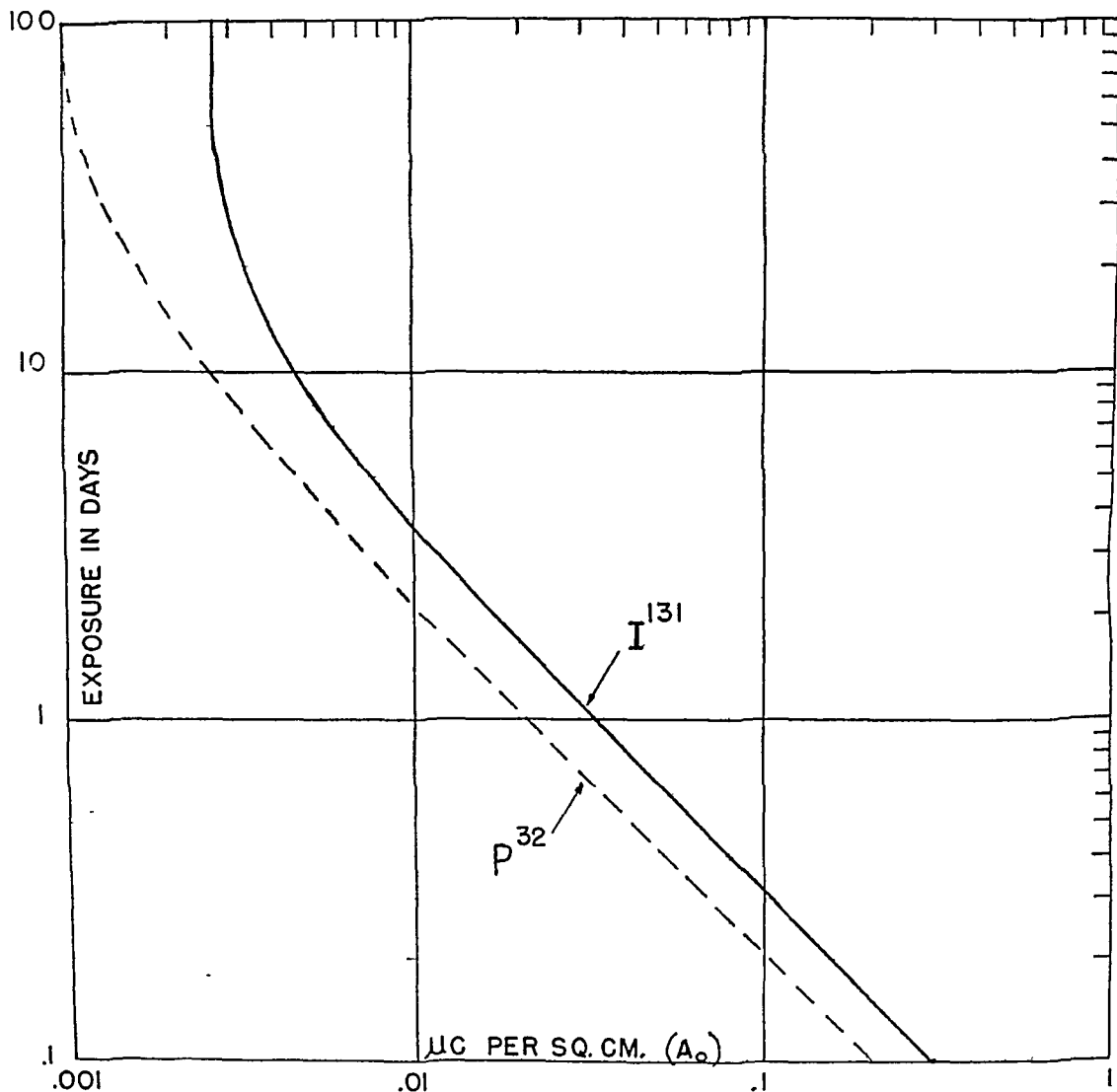


FIG. 4. Exposure time as a function of initial activity for Ansco no-screen x-ray film and photographic density of 0.6.

It must be recognized, however, that the above values of the exposure time are based upon a homogeneous isotope distribution. Therefore, in calculating A_0 for a tissue section, one must divide the measured activity by the area over which the isotope is actually spread. Obviously this cannot be known until a test radioauto-

tion of radioactive iodine can be reduced to a minimum by taking into account that iodine is confined predominantly to the colloid. The ratio of the colloid to follicle volume according to Stein⁶ is close to $1/4$.*

* This figure, obtained by complete serial sectioning of 199 follicles of a normal human thyroid, seems more representative than any other based on mean follicular diameter and mean acinar cell height.

If we assume, moreover, that the area occupied by interfollicular tissue is about equal to the total area occupied by follicles, an overall factor of about 8 is obtained. Thus in the case of sections made from normal or adenomatous tissue of the thyroid gland, one should multiply the apparent activity of unit area (as obtained by counter measurements and overall area of the tissue section) by 8 in order

exposes 3 sections up to the maximum time given by the graph, the results will be quite satisfactory. Figure 5 shows a radioautograph made under these conditions. Here the area containing follicles almost completely surrounds the central non-follicular area. This central portion has large empty spaces in addition to undifferentiated tumor tissue. The estimated ratio of the outside rim to the total area was about

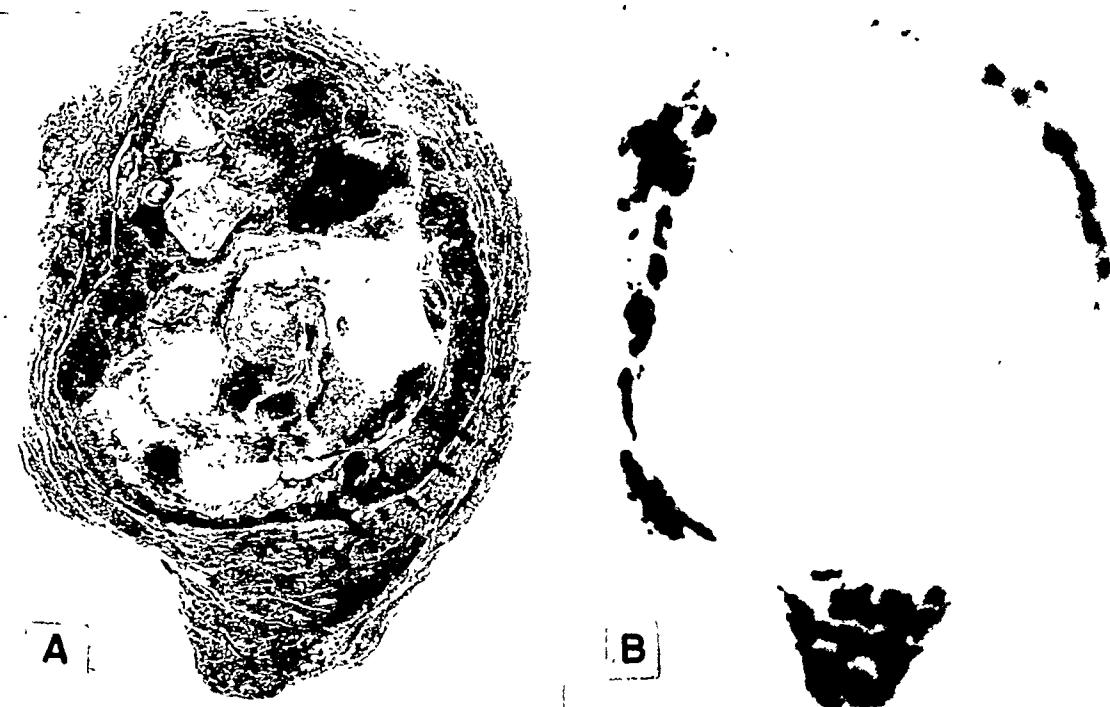


FIG. 5. Tissue section (A) and radioautograph (B) of a Hürthle cell adenocarcinoma. Adjacent thyroid tissue almost completely surrounds the central, tumor area.

to obtain A_0 and hence the exposure time from the graph of Figure 3. In our laboratory 3 sections are exposed routinely for different lengths of time leading up to this graphical value.*

In the case of sections made from thyroid cancers, the ratio of total area to colloid area can be much larger because there may be only isolated groups of follicles, surrounded by large areas of much less differentiated tissue. However, if one estimates what fraction of the entire area appears to be follicular, multiplies this factor by 8, and

$1/2$. The over-all factor was then 8×2 or 16. Multiplying the apparent value of $\mu\text{c}/\text{cm}^2$ by 16, we obtain $A_0 = 0.036$; therefore the required exposure time was fourteen days. Figure 5 is the result of a thirteen day exposure. If A_0 falls below the minimum required, i.e. the value of L , we have been routinely exposing sections for two to three weeks and have obtained at times evidence of I^{131} confined to minute portions of the section.

II. THE TISSUE DOSE

The doses (in equivalent roentgens) which must be given to tissues to obtain adequate radioautographs can be estimated

* Theoretically only two sections should suffice. The third one is exposed routinely to ascertain whether artifacts might be present in the final product.

from the given values of L and the thickness of the specimen. Values of the initial concentration less than L are insufficient to obtain the given photographic density.

If the isotope is administered with the purpose of investigating the deposition of isotopes in the small aggregates of cells, the tissue sections must be thin, usually not over 10 microns on the average. The volume of such a section is obviously at most 0.001 cm.³ for each cm.² of surface. For the case of I^{131} , therefore, the minimum tissue concentrations necessary to obtain radioautographs of density 0.6 are 25 or 2.7 $\mu\text{c}/\text{gram}$ according to whether the plates or the films are used. These concentrations refer to those portions of the tissue in which I^{131} is deposited, the average for the gland being 1/8 of these values, i.e. 3.1 and 0.34 $\mu\text{c}/\text{gram}$ respectively. Since 1 microcurie of I^{131} destroyed per gram of tissue exposes the latter to 144 e.r.,⁴ the concentrations of 25 and 2.7 $\mu\text{c}/\text{gm.}$ correspond to maximal tissue doses of 3,600 and 390 e.r. (or "average" doses of 450 and 49 e.r.) respectively. The use of lower photographic densities would offer some advantage since a density of 0.25 on film gives $L = 5 \times 10^{-4} \mu\text{cd}/\text{cm.}^2$ (see Fig. 2) and a corresponding maximal dose of 72 e.r. and an average dose of 9 e.r. over the gland. The above mentioned figures need downward corrections of the order of 10 to 30 per cent in order to take account of the elimination of I^{131} from the thyroid. As far as biological effect is concerned they cannot be considered a priori wholly equivalent to the same number of roentgens of x-rays. Their magnitudes, however, do pose the question as to whether radioautography of thyroid tissue as practiced at present should be limited only to human cases in which radiation therapy with I^{131} or total thyroidectomy is contemplated. Similar calculations for the case of thin sections containing P^{32} show that the minimum tissue dose necessary for a density of 0.6 in films requires concentrations of 1.0 $\mu\text{c}/\text{gram}$ in 10 μ sections. Since 1 microcurie of P^{32} destroyed per gram of tissue exposes the latter to 885 e.r., the

maximal tissue dose would be $1.0 \times 885 = 885$ e.r.—obviously too high a dose for an isotope so widely distributed in the human body. It is evident that radioautographs with P^{32} could be attempted only in properly dosed terminal cases. A lowering of the photographic density to 0.25 will reduce the above values also to 1/5 (see Fig. 2) and hence should make barely possible the production of radioautographs from some highly selective tissues of patients undergoing therapy.

The methods of Belanger and Leblond² and of Evans³ should be considered at this point. Essentially these investigators attach the tissue sections to the photographic emulsion without glass slide support. Other conditions (type of emulsion, development, etc.) being equal, these techniques should require slightly higher exposures because the scattering effect is less than that for the method described above. The increase, however, cannot be of much practical importance.

It should be noticed from the values given above, that the tissue doses necessary for thin section radioautography with P^{32} are higher than those required for I^{131} . This is a consequence of the fact that the sensitive material of the film or plate utilizes a smaller fraction of the beta-ray energy emitted by P^{32} —the more penetrating of the two—whereas the tissues would, on account of their bulk, absorb practically all in both instances.

The above considerations suggest that the use of faster photographic material is needed if this technique is to find wide clinical application. The graininess of the faster films cannot be considered a drawback because the limiting factor in the magnification of useful detail rests, for the vast majority of radioelements, on the length of their beta-ray tracks. As a matter of fact graininess may well be considered an advantage in many cases since it precludes confusing the photographic with the histological image under the field of vision of a microscope.^{2,3}

When the *distribution* of the radiation

within a tissue, rather than the *localization* of the isotope itself, is being investigated by radioautography, the thickness of the tissue section should be about equal to or larger than the length of the track of the most energetic beta particle emitted by the isotope. For this technique the restrictions mentioned above do not apply. Preliminary investigations into this problem indicate that, for radioactive iodine, the concentration can be reduced by a factor of 30, if a block of tissue instead of a thin section is exposed. It is hoped to consider this problem separately at length and report on it later.

It is of some interest to calculate the number of beta particles, which, incident on a unit area of photographic emulsion, will produce an image of a certain density. Limiting ourselves to the lantern slide plates, we recall that the number L of microcuries destroyed per cm^2 necessary to produce a density of 0.6 is $L = 2.5 \times 10^{-2}$ for I^{131} and $L = 1.2 \times 10^{-2}$ for P^{32} . Moreover, the number of beta particles emitted per microcurie destroyed is $N_0 = 2.3 \times 10^9 \times T$ where T is the half life of the isotope in days.* We obtain therefore $L \times N_0 = 4.6 \times 10^8$ beta rays per square centimeter in the case of I^{131} and 4.0×10^8 beta rays per square centimeter in the case of P^{32} . These values are presented herein with the purpose of indicating only their order of magnitude because under the experimental conditions, a significant amount of scatter from glass plates and slides takes place. It is worthy of notice, however, that Baker *et al.*¹ using a monoenergetic (212 kv.)† beam of electrons directed normally upon the same type of plates obtain a photo-

graphic density of 0.6 when the beam intensity is 1.13×10^9 electrons per cm^2 . This discrepancy, in view of the many factors involved in the experimental conditions, is to be regarded as small.

SUMMARY

A simple method has been described, whereby the uncertainty in exposure time for the production of satisfactory radioautographs is reduced. The graphs correlating activity of tissue section and exposure time necessary to obtain satisfactory results are presented for I^{131} and P^{32} .

An estimate of the radiation dose delivered to tissue shows that the use of the fastest films is indicated and that in general the radioautographic technique with thin tissue sections should be limited to patients undergoing therapy with radioelements.

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REFERENCES

1. BAKER, R. F., RAMBERG, E. G., and HILLIER, J. The photographic action of electrons in the range between 40 and 212 kilovolts. *J. Applied Physics*, 1942, 13, 450.
2. BELANGER, L. F., and LEBLOND, C. P. A method for locating radioactive elements in tissues by covering histological sections with a photographic emulsion. *Endocrinology*, 1946, 39, 8.
3. EVANS, T. C. Radioautographs in which the tissue is mounted directly on the photographic plate. *Proc. Soc. Exper. Biol. & Med.*, 1947, 64, 313.
4. MARINELLI, L. D., QUIMBY, E. H., and HINE, G. J. Dosage determination with radioactive isotopes. II. Practical considerations in therapy and protection. *AM. J. ROENTGENOL. & RAD. THERAPY*, February, 1948, 59, 260-281.
5. MORGAN, R. H. Reciprocity law failure in x-ray films. *Radiology*, 1944, 42, 471-479.
6. STEIN, H. B. The volume of the colloid in follicles of a normal human (Bantu) thyroid gland. *Am. J. Anat.*, 1940, 66, 197-211.

* For this problem, we may assume that one-half the total number of particles are emitted in the direction of the photographic emulsion.

† This energy is close to the average energy, 205 kv. of the beta rays from I^{131} .



THE EFFECT OF ADRENAL CORTICAL INJURY ON THE TOXICITY OF ROENTGEN RAYS*

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THE well known sensitivity of the gonads to roentgen irradiation, coupled with the known interrelationships between the gonads and the adrenal cortices, ably presented in a recent review by Parkes,¹ made it desirable to study the sensitivity of the adrenals to irradiation and the possible effect of that sensitivity upon the survival of exposed animals. Since this experiment was performed a careful search of the literature, but recently available to us, has revealed several pertinent papers of interest which it would appear justifiable to review briefly and correlate since this has not previously been done.

Several investigators have suggested that irradiation sickness might reflect injury to the adrenal cortices.²⁻⁶ Presumably this hypothesis was suggested to these authors not only because of the striking parallelism between the symptoms of Addison's disease and irradiation sickness (Weichert⁷) but also because of evidence of adrenal changes after irradiation. The history of these latter studies has been reviewed by Clark⁸ and more recently by Raab and Soule.⁹ The earlier reports that the adrenals were quite sensitive to irradiation were not confirmed by Desjardins,¹⁰ Frey,¹¹ and Engelstad and Torgersen¹² who concluded the adrenals were no more sensitive than other tissues. The careful histological studies of Frey¹¹ negate many of the earlier clinical impressions. A loss of adrenal cortical lipoid was observed in the victims of an acute radiation death in Japan according to Warren's report¹³ but this may have been evidence only of a general "alarm reaction."¹⁴ Hirsch¹⁵ in 1922 apparently first used an adrenal extract for the treatment of irradiation sickness and reported good results. In

1942 Weichert,⁷ in the only other report of its use that we have found, reported the effect of the administration of 2.5 to 5 mg. of percorten and cortiron, preparations of the adrenal steroids, given partly prophylactically and partly therapeutically to patients exposed to roentgen rays. He noted that the 25 patients so treated were, with few exceptions, improved, especially if the treatment was given prophylactically. It would be sanguine to expect that an agent so universally destructive to biological tissues as roentgen rays could have its lethal effects very markedly diminished by the protection of a single tissue, even though significant differences in the sensitivity of various tissues have been long recognized. Nonetheless, there would be definite clinical application for any therapeutic agent which would permit in a given situation an augmentation of the dose of therapeutically administerable roentgen radiation by raising the threshold dosage above which irradiation sickness and intolerable side effects would appear. This experiment was designed to test the hypothesis that a preferential injury by roentgen irradiation of the adrenal cortices might be a major limiting factor in the patient's toleration of roentgen rays. Leblond and Segal¹⁶ reported that adrenalectomized rats were more susceptible to the lethal action of roentgen rays but they used rats whose adrenals had been removed from two to five days before irradiation. Since no mention was made of replacement therapy one must conclude these rats were already far from normal.

METHOD

Two series of 25 white male rats each (Wistar strain) were exposed in the follow-

* This paper is based on work performed under Contract Number W-7401-eng-49 with the Manhattan Project for the University of Rochester, Rochester, New York. Present address: Department of Pharmacology, Research Division, Ciba Pharmaceutical Products, Inc., Summit, New Jersey.

ing manner to irradiation by roentgen rays: (1) the "protected" rats were covered over the adrenal area of the back with a lead strip 1 inch wide, maintained in that position by confining the rats in cellophane cones; (2) the "unprotected" rats had two $\frac{1}{2}$ inch lead strips shielding them, one over the upper chest and the other over the lower abdomen. Since the 1 inch strip protected the lower chest and upper abdomen, the two $\frac{1}{2}$ inch strips were placed as described so that they might protect approximately equivalent amounts of like tissue. The technical factors of the exposure were as follows: 250 kv., 15 ma.; 24 inch target skin distance, 660 r total dose, 19.6 r per minute output, an exposure of 33 minutes 40 seconds.

The assumed $L.D._{50}$ for the rats was 550 r.¹⁷ Since the strips were estimated to protect about 20 per cent of the exposed animal, the actual dose was augmented by one-fifth so that 660 r was administered to each animal.* All 50 of these rats survived for thirty days after the exposure save 3 of the "unprotected" series which died twelve, twelve, and sixteen days after exposure. Twenty-nine days after the first exposure the same two groups of rats were similarly exposed again but this time to 880 r, since the results after the first exposure had indicated that the assumed $L.D._{50}$ was too low. The technical factors of exposure were as follows: 250 kv., 15 ma., 24 inch target skin distance, 880 r total dose, 21.9 r per minute output, an exposure of 40 minutes.

The filters used for both these exposures were the aluminum parabolic plus 0.5 mm. copper.

After this exposure 2 of the "protected" animals died, one on the fourth and one on the twelfth day after exposure. Seven of the "unprotected" animals died on the third, ninth, sixteenth, seventeenth, twenty-fourth, twenty-sixth and thirtieth days after this exposure, after which the remaining animals were destroyed. In the "protected" series, 3 rats were obviously in poor

health as evidenced by a roughened fur and obvious weight loss. In the "unprotected" series 6 rats were in poor condition.

Mr. David Tiedeman very kindly analyzed the foregoing data statistically and submitted the following values: $\chi^2 = 5.3728$; $P = 0.0205$. It is thus apparent that the measure of protection afforded in these experiments could have resulted from chance in only one trial out of fifty.

DISCUSSION

If one accepts the hypothesis that the major factor decreasing the toxic action of roentgen rays in this experiment was the protection accorded the adrenals, admittedly a debatable assumption in view of the literature earlier reviewed, then certain speculations are suggested. (It is at least reasonable to postulate that the adrenal cortical output per day was decreased in the "unprotected" animals.) White¹⁸ reported that small doses of roentgen rays would produce disruptive changes in the lymphocytes of mice and that the production of equivalent changes in adrenalectomized mice required a twenty-fold increase in the dose of radiation. Dougherty, White and Chase¹⁹ have previously reported evidence that nonspecific poisons can cause a destruction of lymphocytes in animals whose adrenals are intact. It seems possible that the markedly increased activity of the adrenal cortices after injury may lead, among other changes, to an extensive breakdown of lymphocytes and that the products of that breakdown play a major role in subsequent tissue repair. Thus undue adrenal injury might prevent the release of adequate amounts of hormones for a sufficient length of time although it is also possible a suitable dose might cause the release of such large amounts of hormone in answer to the increased demands as to exceed the capacity of the lymphoid tissue to respond. Since competent investigators have not been able to agree on the sensitivity of the adrenal cortices to the effects of roentgen radiation, the most reasonable explanation would be the assumption that

* Obviously an approximate correction because of such indeterminable variables as scattering, and so forth.

unknown variables are altering the results in an inconstant manner. All these seemingly unrelated facts might be explained by the hypothesis that the general tissue damage caused by roentgen rays requires the protein products of lymphoid tissue for repair and that these proteins are made available by adrenal cortical activity. The breaking of any of the three links in this chain—adrenal cortical activity, availability of lymphoid proteins, and actual tissue repair—would sharply limit the organism's capacity for recovery from the damage caused by a given dose of roentgen rays. Such a concept would accord well with Spiegelman and Kamen's²⁰ recently advanced hypothesis, if one assumed the self-duplicating nucleoprotein replicas and not the genes were primarily affected. The latent period between exposure to roentgen rays and the onset of symptoms could then be viewed as the interval during which the replicas and the enzymes derived therefrom were exhausted. One could then proceed on the hopeful assumption that the supplying of adequate raw materials during that latent period might permit the organism to restore homeostasis within the damaged cells. The perhaps more probable hypothesis that irreversible damage to the cell's genes had occurred would allow us no good method of remedial attack in the light of our present knowledge. Albeit, even if we accept this latter hypothesis, it might still be argued that supplying to the tissues adequate raw materials would accelerate the multiplication of undamaged cells.

If one accepts the foregoing reasoning, it would appear that potentially fatal exposure to roentgen rays might theoretically respond favorably to adequate amounts of adrenal cortical hormones and transfusions of lymphocytes, on the assumption that that would allow sufficient tissue repair to permit the organism to restore homeostasis. A practical approach might be the administration of the proteins, and so forth, derived from lymphocytes plus the adrenal cortical hormone. The single experiment herein reported is of little value but the

courses suggested by it are being pursued.

The report of Lofstrom and Nurnberger²¹ came to our attention since this paper was written. They secured dramatic results in the treatment of irradiation sickness by the injection of benadryl, an antihistaminic drug. Segal's²² report that the histamine concentration in the blood of irradiated patients is increased may offer a reasonable experimental basis for such treatment. It would seem in conclusion as though a multiple therapeutic approach to the treatment of irradiation sickness might be justified because of the multiple nature of the roentgen ray's destructive effects. A combination of an antihistaminic drug, adrenal cortical hormones, liver extract and the B vitamins might give even better therapeutic results than any single agent thus far administered. The author hopes this idea may be evaluated by interested clinicians with the proper facilities for such a study.

SUMMARY

Evidence is presented suggesting that rats whose adrenals are protected from roentgen irradiation are less susceptible to its lethal effects than rats receiving equivalent doses but not so protected. The possible relation of the adrenal-lymphoid system to irradiation sickness and the lethality of roentgen radiation has been discussed.*

The author thanks Mr. Francis Bishop for arranging the exposures in this experiment, and Miss Mildred Taylor and Mrs. Florence Van Slyke for technical assistance.

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REFERENCES

1. PARKES, A. S. Adrenal-gonad relationship. *Physiol. Rev.*, 1945, 25, 203-254.
2. HEINEKE and PERTHES. Die biologische Wirkung der Röntgen- und Radiumstrahlen. From H. Meyer's *Lehrbuch der Strahlentherapie*, Bd. I.

* Since this paper was written, Ellinger²³ has reported the value of desoxycorticosterone in preventing roentgen-ray induced hepatic changes in rats. He suggests that it acts by opposing the effects of histamine but it would appear to us that it can oppose the action of histamine only in the sense that the "general adaptation syndrome" is the organism's response to many toxic materials.

3. NARAT, J.A.M.A., 1922, 79, 1681-1684.
4. THADDEA, S. Klinische Erscheinungsformen der Nebenniereninsuffizienz. *Klin. Wchnschr.*, 1940, 19, 145-151.
5. STEINBERG, S. S. Irradiation sickness. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 56-65.
6. JENKINSON, E. L., and BROWN, W. H. Irradiation sickness; hypothesis concerning the basic mechanism and a study of the therapeutic effect of amphetamine and dextro-desoxyephedrine. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1944, 51, 496-503.
7. WEICHERT, URSULA. Die Behandlung des sogenannten "Strahlenkaters" mit desoxycorticosteron. *Strahlentherapie*, 1942, 71, 127-138.
8. CLARK, G. L. Effects of x-radiation on cell structure and growth; general survey of radiobiology, *Cold Spring Harbor Symp., Quant. Biol.*, 1934, 2, 249-263.
9. RAAB, W., and SOULE, A. B., JR. Rationale and results of roentgen treatment of adrenal glands in angina pectoris. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1944, 51, 364-377.
10. DESJARDINS, A. U. Effect of irradiation on suprarenal gland. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1928, 19, 453-461.
11. FREY, H. Experimentelle Untersuchungen über die Röntgensensibilität der Nebennieren. *Acta radiol.*, 1928, 9, 23-53.
12. ENGELSTAD, R. B., and TORGENSEN, O. Experimental investigations on effects of roentgen rays on suprarenal glands in rabbits. *Acta radiol.*, 1937, 18, 671-687.
13. WARREN, S. Pathologic effects of an instantaneous dose of radiation. *Cancer Research*, 1946, 6, 449-453.
14. SELYE, H. General adaptation syndrome and diseases of adaptation. *J. Clin. Endocrinol.*, 1946, 6, 117-230.
15. HIRSCH, H. Zum Problem des Röntgenkaters. *Strahlentherapie*, 1923, 14, 679-684; also, *Deutsche med. Wchnschr.*, 1922, A-646.
16. LEBLOND, C. P., and SEGAL, G. Differentiation between the direct and indirect effects of roentgen rays upon the organs of normal and adrenalectomized rats. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 302-306.
17. POTTER, J. C. Biological effect of roentgen rays of long and short wavelength on the totally irradiated rat. *Radiology*, 1941, 37, 724-725.
18. WHITE, A. Factors influencing serum globulin formulation. Symposium on Body Proteins, University of Buffalo, Sept., 1946.
19. DOUGHERTY, T. F., CHASE, J. H., and WHITE, A. Pituitary-adrenal cortical control of antibody release from lymphocytes. Explanation of the anamnestic response. *Proc. Soc. Exper. Biol. & Med.*, 1945, 58, 135-140.
20. SPIEGELMAN, S., and KAMEN, M. D. Genes and nucleoproteins in synthesis of enzymes. *Science*, 1946, 104, 581-584.
21. LOFSTROM, J. E., and NURNBERGER, C. E. Irradiation sickness; histamine effect treated with benadryl. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1946, 56, 211-219.
22. SEGAL, G. Variations du taux d'histamine chez des malades soumis à un traitement par rayons X. *Compt. rend. Soc. de biol.*, 1939, 131, 1079-1080.
23. ELLINGER, F. Protective action of desoxycorticosterone acetate against x-ray-induced liver changes. *Science*, 1946, 104, 502-503.



EXPERIMENTAL STUDIES ON THE TOXICITY OF BETA-(4-HYDROXY-3,5-DIIODOPHENYL)-ALPHA-PHENYL-PROPIONIC ACID (PRIODAX)*

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DICK and Wallace¹ in 1928 reported on the toxicity of tetraiodophenolphthalein to pancreatic tissue. The dye, widely used in cholecystography, is absorbed from the gastrointestinal tract and excreted largely by the liver but partly by the kidneys. From their experiments on cats and rabbits Dick and Wallace concluded,

It may thus be inferred that in cases of cholelithiasis, in which stones are present in the common duct and the conditions are otherwise favorable for the retrojection of bile in the pancreas, the danger of acute pancreatitis occurring will be much greater if the regurgitated bile contains the phenolphthalein salt.

In obstructive jaundice the normal route of elimination of the drug is unavailable, and small quantities are excreted in the pancreatic juice. In animals with experimental biliary obstruction, especially in rabbits, it was found that pathological changes occurred in the pancreas ranging from simple vascular congestion to hemorrhagic pancreatitis. The conclusion to be drawn from this is that there is risk of damage to the pancreas by the administration of the agent to jaundiced patients who have chronic obstructive lesions of the biliary tree.

Partially as a result of this warning many roentgenologists, internists and surgeons have been hesitant to use tetraiodophenolphthalein for cholecystography in the presence of obstruction to the extrahepatic biliary tract or in suspected pancreatitis.

In 1940 a new dye for cholecystography, beta-(4-hydroxy-3,5-diiodophenyl)-alpha-phenyl-propionic acid, was introduced. It was marketed abroad under the trade name biliselectan and later in America under the trade name of priodax. In this paper it will be referred to by the latter trade name.

The dye contains 51.5 per cent iodine by weight. Wasch² described it as being readily absorbed from the gastrointestinal tract through the portal circulation and excreted in part through the liver, the iodine being said to remain in organic combination as it passes through the body.

Modell³ studied the pharmacology of priodax and found in cats that an intravenous injection of 75.0 mg. per kilogram of body weight produced picROTOXIN-like, medullary convulsions. Postmortem examination revealed no abnormal findings except in one instance where pulmonary petechiae were found. When the drug was given orally to the cat, vomiting was not unusual, but this was controlled by the administration of morphine.* One hundred milligrams per kilogram of body weight given orally produced, in some instances, transient albuminuria. However, doses ten times as great, that is 1,000 mg. per kilogram did not affect phenolsulphonphthalein excretion, the non-protein nitrogen level in the blood, red cell count, red cell fragility or blood clotting time. There was no microscopic evidence of renal damage. In two of fifteen experiments one cat receiving 500 mg. per kilogram of body weight had a non-protein nitrogen level of 127 mg. per cent and another cat on the same dosage had cloudy swelling of the renal tubules.

Junkmann⁴ showed that after the dye had been administered orally 50 per cent was excreted in the urine within twenty-four hours and that 61 to 83 per cent was excreted within seventy-two hours.

* In the cat stimulation of the central nervous system by morphine is not unusual and vomiting frequently results.

* From the Harrison Department of Surgical Research, School of Medicine, University of Pennsylvania, Philadelphia.

Reports on the use of the drug in several thousand patients indicate its wide clinical use.^{2,5-13}

In order to extend the studies made with the drug and to determine its effect on pancreatic tissue, additional experiments were undertaken in our laboratory. Cats and dogs were used as the experimental animals. Open drop ether, endotracheal ether or parenteral pentobarbital anesthesia was used. Priodax concentration was determined by adaptation of the method de-

grams priodax orally. No pancreatic disease, biliary obstruction or acute biliary disease was suspected in these patients. Roentgen visualization of the gallbladder occurred in each instance. Serum amylase concentration was determined by the modified Somogyi method as described by Elman.¹⁶ Determinations were made immediately before the administration of the dye and again six to forty-eight hours following its administration. Duplicate determinations were made in each instance.

TABLE I
PRIODAX ORALLY TO NORMAL ANIMALS

Animal No.		Dosage of Priodax per Kilogram of Body Weight	Time Elapsed between Administration of Drug and Examination of Pancreas	Appearance of Pancreas
		mg.	hrs.	
Cat	6	250	24	Grossly normal
	10	250	24	Grossly normal
Dog	400	1,096	22	Grossly normal
	986	500	24	Grossly normal
	918	450	48	Grossly and microscopically normal
	919	450	48	Grossly and microscopically normal

scribed by Chiray and others for iodine determinations.^{14,15}

The Effects of Priodax on the Pancreas under Normal Conditions. Four normal dogs and two normal cats were used (Table I). Each dog was given 3.0 grams of priodax by mouth or stomach tube. This dosage was 400 to 500 mg. per kilogram of body weight. The cats were given 500 mg. of the dye by mouth, that is, approximately 250 mg. per kilogram. Twenty-four hours later laparotomy was performed; the pancreas was examined, and the iodine concentration in the gallbladder bile was determined (Table v). Grossly the pancreas appeared normal in each instance, and in two dogs where microscopic study was done, no histologic evidence of damage was found.

In the clinic an attempt was made to demonstrate possible pancreatic damage by serum amylase determinations on nine patients, each of whom had been given 3.0

Table II indicates the results. There was no significant change in any instance.

The Effects of Priodax on the Pancreas in Cases of Obstruction of the Common Bile Duct. Six dogs and two cats were used for determination of possible injury to the pancreas in the presence of recent common duct obstruction. Using a sterile technique the common bile duct was doubly ligated. Eighteen hours later 0.5 to 3.0 grams of priodax (Table III) were given orally. Vomiting was not noted in any case after the drug was given.

A second laparotomy was performed on the first to seventh day following administration of the drug. In each instance a distended gallbladder and common duct were found. The pancreas was examined, and a section was taken for microscopic examination. Bile was then aspirated from the gallbladder and analyzed for iodine. Four of the dogs were sacrificed on the seventh

day after the dye was given and the pancreas re-examined.

The pancreas appeared normal except in two instances. Dog No. 432 had a slight

dye was given, the pancreas appeared normal except for a single plaque of fat necrosis in the tail at the site of the previous biopsy.

TABLE II
EFFECTS OF PRIODAX (3.0 GRAMS ORALLY) ON SERUM AMYLASE OF PATIENTS

Patient	Serum Amylase Concentration Before Priodax Given	Time Elapsed between Administration of Dye and Second Analysis	Serum Amylase Concentration After Priodax Given
No.		hrs.	
1	140 132	24	145 140
2	110 110	24	110 100
3	110 130	24	100 115
4	180 170	18	150 155
5	88 95	18	110 118
6	115 125	18	100 118
7	150 138	6 24 48	165 152 165 150 152 170
8	105 102	48	108 96
9	88 80	6 12	115 130 100 104

subcapsular hemorrhage into the pancreas. This was found on the first day following the administration of the dye and was considered as probably due to the trauma of the first laparotomy. A section of the tail of the pancreas of Dog No. 1132 was obtained for microscopic study at the time of the common duct ligation. Four days after the

In order to control this observation biopsy was performed on the pancreas of one dog and one cat five days after ligation of the common bile duct. Grossly and microscopically the pancreas appeared normal.

Effects of Priodax Suspended in Physiological Saline Solution When Injected into the Pancreatic Duct. Seven dogs and four

cats were used in these experiments (Table iv). The major pancreatic duct was exposed by blunt dissection and ligated at its entrance into the duodenum. A No. 27 needle was then inserted into the pancreatic duct, and, in the dogs, 1.0 to 2.0 cc. of a suspension of 500 mg. of priodax in 100 cc. of physiological saline solution were injected

pancreatic duct. There was no immediate reaction. Twenty-four hours later a specimen of the pancreas was taken. At that time the pancreas was normal except at the site of the ligation of the duct where there was hemorrhage and fat necrosis with some fat necrosis of the surrounding omentum. Forty-eight hours after the original oper-

TABLE III
PRIODAX ORALLY—OBSTRUCTION OF COMMON DUCT

Animal No.	Dosage of Priodax Per Kilogram of Body Weight	Concentration of Iodine in Gallbladder Bile	Time Elapsed between Administration of Drug and Examination of Pancreas	Appearance of Pancreas
Dog 1,132	mg. 350	mg. % 25.0	Days 4	Normal except for single plaque of fat necrosis
1,142	400	30.0	6	Normal
432	200	22.0	1 7	Slight subscapular hemorrhage Normal
433	150	10.0	3 7	Normal Normal
434	180	32.0	3 7	Normal Normal
435	150	5.0	3 7	Normal Normal
Cat 5	250	4.4	5	Normal
6	250	10.0	2	Normal

very slowly and under very low pressure into the duct. The duct was then ligated proximal to the needle so as to prevent leakage. Analysis of the suspension showed the amount of priodax injected to range from 0.8 to 4.2 mg. In cats 0.6 to 0.75 mg. of the dye in 0.5 cc. to 0.75 cc. of saline was injected into the duct.

Of the seven dogs, only one, No. 989, showed evidence of injury. This dog had 2.0 cc. physiological saline solution containing 4.0 mg. of priodax injected into the

pancreatic duct. Autopsy confirmed the pancreatic damage.

Several dogs were followed for two months without evidence of residual damage. The pancreas of the cats showed very slight damage. This consisted of a localized edema or fat necrosis at the site of the ligation.

As controls, 0.5 cc. to 2.0 cc. of physiological saline solution were injected into the main pancreatic duct of three dogs and two cats, and the duct was then ligated as

in the above experiments. Biopsy of the pancreas was then done twenty-four to seventy-two hours later. The pancreas appeared slightly edematous in several instances, and there was slight fat necrosis of the pancreas in one cat.

was then done twenty-four to seventy-two hours later. In no case was there leakage of bile from the gallbladder at the point of aspiration.

These experiments were repeated on three cats. Five hundred milligrams of

TABLE IV
PRIODAX IN PHYSIOLOGICAL SALINE SOLUTION

Animal No.	Amount of Priodax Injected	Amount of P.S.S. Injected	Time Elapsed between Injection of Dye and Examination of Pancreas	Appearance of Pancreas
	mg.	cc.	hrs.	
EXPERIMENTAL				
Dog 309	0.80	1.00	72	Normal
310	1.30	1.00	72	Normal
191	4.20	2.00	72	Normal
268	2.50	2.50	24 72	Normal Normal
989	4.00	2.00	24 48	Fat necrosis; hemorrhage; death of animal
1,091	4.20	2.00	72	Normal
1,093	3.60	2.00	24	Normal
Cat 3	0.60	0.50	96	Slight edema
4	1.20	0.75	72	Slight edema
8	0.80	0.50	48	Fat necrosis (one plaque)
9	0.75	0.50	48	Fat necrosis (one plaque)
CONTROLS				
Dog 80		1.00	24	Normal
81		1.50	72	Slight edema
84		2.00	72	Normal
Cat 12		0.50	72	Edema
14		0.50	72	Edema; slight fat necrosis

Injection of Gallbladder Bile Containing "Priodax" into the Pancreatic Ducts. Four dogs and three cats were used in this experiment. The dogs were given 3.0 grams of priodax orally. Approximately twenty-four hours later bile was withdrawn from the gallbladder, and 1.0 cc. was injected over a period of three minutes into the pancreatic duct as in the previous experiments. Analysis of the bile was done for iodine concentration (Table v). Biopsy of the pancreas

priodax were given orally. Twenty-four hours later 0.5 cc. of gallbladder bile was injected into the pancreatic duct as above.

In almost every instance there was marked injury of the pancreas, consisting of a polymorphonuclear exudate, edema and fat necrosis.

Controls. Four dogs and three cats were used as controls. By the previously described technique 0.5 cc. of bile was aspirated from the gallbladder and injected into

the pancreatic duct of each cat and 1.0 cc. into the duct of each dog. There was no leakage of bile from the gallbladder in any instance. As in the above experiment pancreatic injury was widespread. Fat necrosis, mild hemorrhage and polymorphonu-

pancreatic duct is a possibility, and (4) following shortly after or during an attack of acute pancreatitis.

The results of the studies in the animals with unobstructed biliary tracts indicate that there was no damage to pancreatic

TABLE V
BILE CONTAINING "PRIODAX" INTO PANCREATIC DUCT

Animal No.	Amount of Bile Injected	Concentration of Iodine in Gallbladder Bile	Time Elapsed between Injection of Bile and Examination of Pancreas	Appearance of Pancreas
	cc.	mg. %	hrs.	
EXPERIMENTAL				
Dog 1,096	1.0	10.0	72	Slight inflammatory reaction
986	1.0	28.0	24	Fat necrosis
918	1.0	18.0	48	Inflammatory reaction
919	1.0	30.0	48	Normal
Cat 26	0.5	20.0	48	Fat necrosis
10	0.5	15.0	48	Fat necrosis
6	0.5	3.0	24	Normal
CONTROLS				
Dog 21	1.0		24 48	Fat necrosis; hemorrhage; death of animal
22	1.0		72	Normal
23	1.0		48	Slight fat necrosis
25	1.0		48	Inflammatory reaction
Cat 1	0.5		84 96	Fat necrosis Fat necrosis
2	0.5		84 96	Fat necrosis Fat necrosis
11	0.5		24	Fat necrosis; hemorrhage

clear exudate was found in almost every instance.

DISCUSSION

These studies were undertaken in order to determine the safety of priodax in cholecystography in regard to the pancreas, (1) in uncomplicated cases of chronic cholecystitis, (2) in cases of obstruction to the extrahepatic biliary tract before marked jaundice, (3) in cases of stone in the common duct where reflux of bile into the

tissue demonstrable by gross or histologic study. Amylase studies would not necessarily reflect pancreatic injury but are of interest since acute hemorrhagic pancreatitis has been reported following the administration of tetraiodophenolphthalein.

If, like tetraiodophenolphthalein, in the presence of acute extraheptic biliary obstruction a small part of the dye is excreted by the pancreas, there is little, if any, evidence by microscopic study that injury to pancreatic tissue results.

There is no evidence that priodax is excreted without some chemical alteration by the liver. Because of this possibility the concentration of the dye in gallbladder bile cannot be determined by the above methods, but instead the concentration of iodine is obtained. Duplicate iodine determinations did not indicate a consistent high degree of uniformity, and the iodine concentrations are, therefore, offered more for qualitative than quantitative purposes, that is, to prove the absorption of the dye and its presence in the bile. Evaluation of the results of the injections of priodax in physiological saline solution must, therefore, include the probability that this is not the form in which the dye reached the common bile duct.

Many investigators¹⁷⁻²² have shown that the injection of bile into the pancreatic duct produces marked injury to the pancreas and frequently produces acute hemorrhagic pancreatitis. The results in the above experiments in which bile was injected into the pancreatic duct were therefore to be expected. No difference was found in the injury to pancreatic tissue resulting from the injection of bile and the damage produced by the bile containing the dye.

SUMMARY

1. Beta-(4-hydroxy-3,5-diiodophenyl)-alpha-phenyl-propionic acid, given orally to dogs and cats in doses of 250 to 500 mg. per kilogram of body weight, caused no gross or microscopic change in pancreatic tissue.

Serum amylase determinations immediately before and six to forty-eight hours after the administration of 3.0 grams of this dye orally to nine patients with unobstructed extraphepatic biliary tracts showed no significant change.

2. The dye, in doses of 150 to 400 mg. per kilogram of body weight, was given orally to dogs and cats following recent ligation of the common bile duct. Fat necrosis was found in only one dog, and this was at the site of a previous biopsy. In all other animals evidence of resultant damage was lacking.

3. A suspension of priodax in physiological saline solution, 0.5 cc. to 2.0 cc., was injected into the main pancreatic duct of dogs and cats. One dog died forty-eight hours after injection with acute hemorrhagic pancreatitis. Gross and microscopic study of the pancreas of the other animals showed little, if any, difference from the pancreas of the control animals which had been injected with equal amounts of physiological saline solution.

4. Bile injected into a pancreatic duct of the dog produced such severe injury to the pancreas that the added effect, if any, of dye in the bile could not be properly evaluated.

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REFERENCES

1. DICK, B. M., and WALLACE, V. G. H. Cholecystography; toxic effects of dyes; clinical and experimental study. *Brit. J. Surg.*, 1928, 15, 360-369.
2. WASCH, M. G. New medium for gallbladder visualization. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1943, 50, 677-679.
3. MODELL, W. Pharmacology of $\beta(3,5$ di-iodo-4-hydroxyphenyl) α phenyl propionic acid. *J. Lab. & Clin. Med.*, 1942, 27, 1376-1384.
4. JUNKMANN, K. Perorale Cholecystographie mit Biliselectan. *Klin. Wchnschr.*, 1941, 20, 125-128.
5. EINSEL, I. H., and EINSEL, T. H. Gall bladder visualization with $\beta(3,5$ di-iodo-4-hydroxyphenyl) α phenyl propionic acid (priodax). *Am. J. Digest. Dis.*, 1943, 10, 206-208.
6. WEBER, H. M. New cholecystographic medium. *Am. J. M. Sc.*, 1944, 207, 678-680.
7. DANNENBERG, M. Cholecystographic studies with priodax. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1944, 51, 328-335.
8. OCHSNER, H. C. New cholecystographic preparation. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1944, 51, 326-327.
9. KEMP, F. H. Pheniodol; new contrast medium for cholecystography. *Brit. M. J.*, 1943, 2, 674-676.
10. HEFKE, H. W. Cholecystography with priodax; report on 600 examinations. *Radiology*, 1944, 42, 233-236.
11. VAUGHAN, W. W., and EICHWALD, M. Priodax; contrast medium for cholecystography. *Radiology*, 1944, 43, 578-581.

12. MARSHALL, W. A. Some observations on priodax. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1943, 50, 680-682.
13. NAUMANN, W. Die Brauchbarkeit des neuen Gallenblasenkontrastmittels Biliselectan. *Med. Klin.*, 1941, 37, 968-969.
14. CHIRAY, M., LESAGE, J., and TASCHNER, E. L'élimination hépatique de la tétraiodophénolphtaléine et ses rapports avec la cholécystographie. *Presse méd.*, 1931, 39, 1605-1608.
15. JOHNSON, J., ELLIS, A. L., and RIEGEL, C. Studies of gall bladder function; absorption of sodium tetraiodophenolphthalein from normal and damaged gall bladder. *Am. J. M. Sc.*, 1937, 193, 483-488.
16. ELMAN, R. Variations of blood amylase during acute transient disease of pancreas. *Ann. Surg.*, 1937, 105, 379-384.
17. OPIE, E. L. *J.A.M.A.*, 1904, 43, 1102.
18. POPPER, H. L., and NECHELES, H. Pathways of enzymes into blood in acute damage of pancreas. *Proc. Soc. Exper. Biol. & Med.*, 1940, 43, 220-222.
19. MELTZER, S. J., and SALANT, W. *J. Exper. Med.*, 1906, 8, 127.
20. FLEXNER, S., and PEARCE, R. M. *Univ. Pennsylvania Med. Bull.*, 1901, 14, 193.
21. ARCHIBALD, E., and BROW. *Canad. J. Med. & Surg.*, 1913, 33, 262.
22. WANGENSTEEN, O. H., LEVEN, N. L., and MANSON, M. H. Acute pancreatitis (pancreatic necrosis); experimental and clinical study, with special reference to significance of biliary tract factor. *Arch. Surg.*, 1931, 23, 47-63.



TWO DANISH PHOTOFLUOROGRAPHIC CAMERAS OF THE ORIGINAL SCHMIDT TYPE*

PAPER III†

By RUSSELL H. MORGAN, M.D., DAVID M. GOULD, M.D.,
and WILLARD W. VANALLEN, B.Sc.

AS EARLY as 1938, the Danish engineer Helm began applying Schmidt optics to photofluorography. After several years

of research two cameras, one using 35 mm. perforated film and the other using 70 mm. perforated film, were developed. Within recent months models of both cameras have been brought to the United States by the Tuberculosis Control Division, United States Public Health Service. After minor changes which permitted their adaptation to American photofluorographic equipment, these cameras were subjected to laboratory and field tests to evaluate their characteristics.

Photographs of the two cameras are illustrated in Figures 1, 2 and 3 and schematic diagrams of their essential parts are shown in Figures 4 and 5. In the main, both cameras are of simple Schmidt design and consist essentially of a forward aspherical single-element lens, and a rear spherical mirror. The 35 mm. camera also includes a wide-angle lens approximately 16 inches in front of the aspherical correcting lens. The



FIG. 1. Closed view of Helm 35 mm. camera.

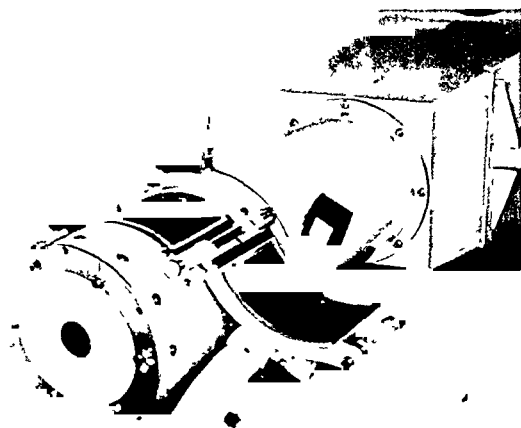


FIG. 2. Open view of Helm 35 mm. camera.

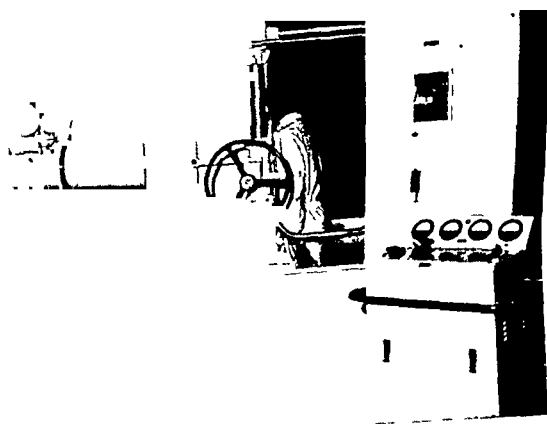


FIG. 3. Helm 35 mm. camera installed on photofluorographic unit.

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† For Papers I and II in this series see AM. J. ROENTGENOL. & RAD. THERAPY, January, 1948, 59, 122-131; February, 1948, 59, 282-289.

TABLE I

Lens Characteristics	Camera	
	35 mm.	70 mm.
Mirror		
Diameter	9 in.	12 in.
Radius of curvature	9 in.	13 in.
Aperture	$6\frac{1}{8}$ in.	$8\frac{3}{8}$ in.
Focal length*	4 in.	6 in.
f/number		
(theoretical)*	0.65	0.70
Reduction of aperture		
by film carrier**	21%	32%
Effective f/number*	0.75	0.85
Resolving power**		
Center	25 lines/mm.	16 lines/mm.
Edge	17 lines/mm.	16 lines/mm.
Corner	12 lines/mm.	16 lines/mm.
Minification**	15.5 diameters	7.4 diameters

* Approximate.
** Measured by National Bureau of Standards.

film carrier mechanism occupies a position between the correcting lens and mirror and is arranged so that the emulsion surface of the film faces the mirror. Furthermore, the film is curved spherically with its center of curvature coinciding with that of the mirror. The cameras are cylindrical

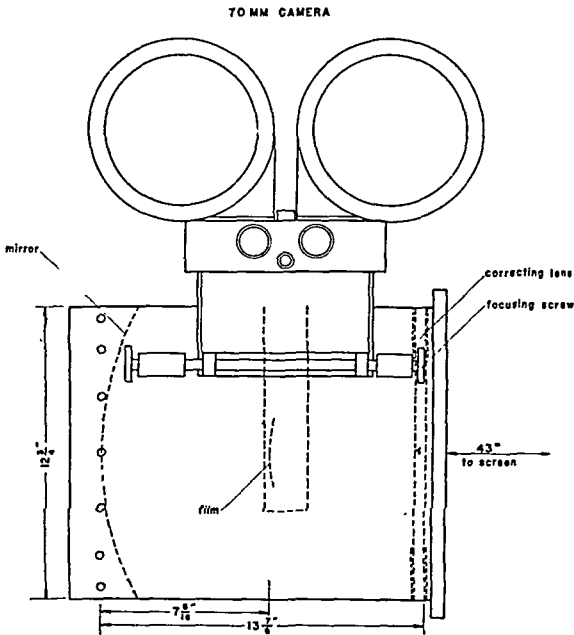


FIG. 5. Schematic diagram of Helm 70 mm. camera.

in shape and are made of aluminum. In spite of their large size, the cameras therefore are not unusually heavy (50 lb. for the 35 mm. camera and 72 lb. for the 70 mm. camera).

The characteristics of the two lens systems employed in the Helm cameras are

35 MM CAMERA

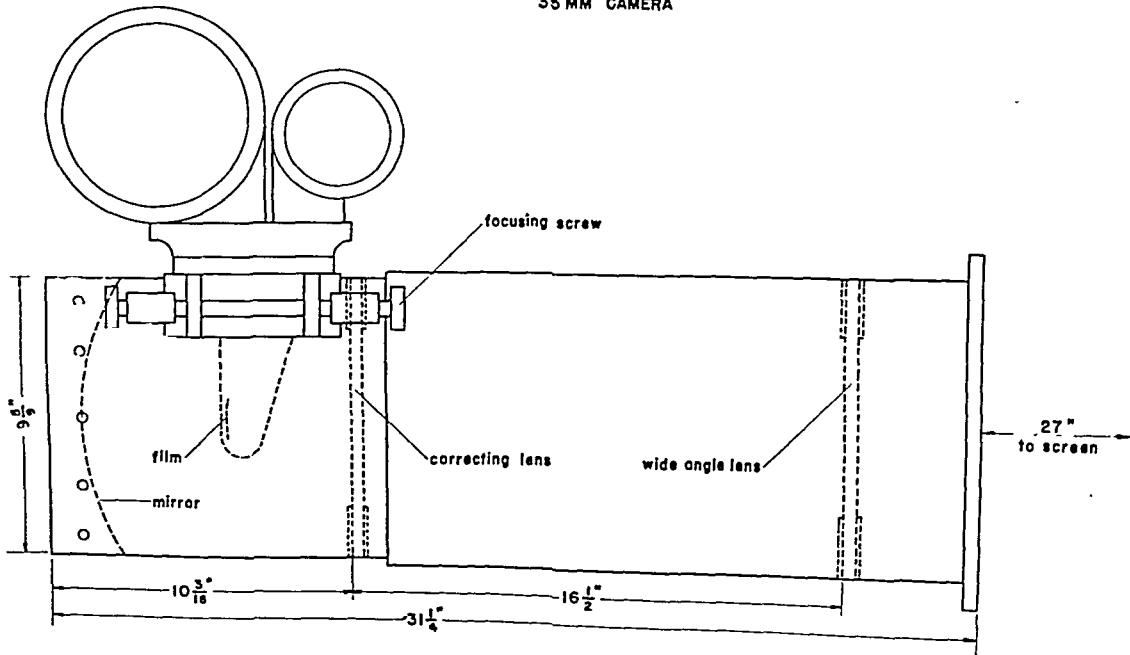


FIG. 4. Schematic diagram of Helm 35 mm. camera.

listed in Table 1. It will be observed that the theoretical f /numbers of the 35 and 70 mm. cameras are respectively 0.65 and 0.70. However, the effective or practical f /numbers are 0.75 and 0.85 respectively since the apertures of the two lenses are encroached upon by the film carriers. It is noteworthy that in spite of this aperture reduction the speeds of the two lenses are unusually high. Indeed, their speeds are many times those of conventional photofluorographic cameras ($f/1.5$) now in use in the United States.

In general the speed of an optical system is inversely proportional to the square of the f /number. However, this index is not entirely reliable when the object being photographed is a short distance from the lens as in the case of the photofluorographic screen. Accordingly, tests were carried out to determine the comparable amounts of roentgen-ray energy needed to produce a particular blackening of the photofluorographic film within the Helm cameras and within conventional American Recordak and Fairchild cameras. The Recordak camera employing 35 mm. film and the Fairchild camera employing 70 mm. film were equipped with Eastman Ektar $f/1.5$ lenses. The measurements derived from these tests indicate that the Helm 35 mm. camera is 4.5 times faster than the Recordak camera and the Helm 70 mm. camera is 6 times faster than the Fairchild camera. Both of these values are somewhat higher than that which may be predicted from a consideration of the f /numbers of the four lens systems alone. Part of this difference may be attributed to the simplicity of the optical system of the Schmidt lenses. The amount of glass through which the light must pass before it falls upon the photofluorographic film is extremely small. Second, the number of reflecting surfaces within the lens is considerably smaller than in conventional optical systems. Furthermore, Helm constructed his lenses of uviole glass which has a high transmission, not only within the visible spectrum but also within the ultraviolet region. Thus, if there is any

light emitted by the fluorescent screen in the ultraviolet region this light would be effective in producing film blackening in the Helm camera.

One of the interesting features of the Schmidt optical system is its relatively high resolving power or ability to record detail, not only within the center of the field but also at the peripheral portion of the frame. This characteristic is particularly well shown by Helm's 70 mm. camera where the resolving power is uniformly 16 lines per millimeter throughout the entire field.

In the Helm cameras the film magazine and receiver are attached to the film carrier mechanism in the positions shown in the schematic diagrams. Film is fed from the magazine through a light lock, over sprocket wheels and around the film carrier back to the receiver over a second sprocket. Film advance is obtained manually by means of a cord attached to a sliding bar in the 35 mm. camera and a quadrant sector wheel in the 70 mm. camera. During the operation of the film advance mechanism, the pressure plate is first relaxed, and the film then moved forward one frame. Upon release of the film advance lever pressure is again applied to the pressure plate. Since film advance is actuated and metered by sprocket wheels, perforated film is required. The film magazine holds over 500 feet of film. However, after any number of pictures have been taken the film may be cut in daylight and the receiver removed.

The curvature of the pressure plate in the 35 mm. camera is not great enough to cause buckling of conventional 35 mm. film. In the 70 mm. camera, however, ordinary thin-base film does not lie flat against the curved pressure plate and it is necessary to use film with a base not less than 0.008 in. (0.2 mm.) in thickness. Film even heavier than this is recommended. Focusing the cameras is accomplished by means of a micrometer screw and lock screw mechanism which shifts the whole film carriage along the axis of the camera.

The adjustment is extremely critical and must be done with great care to insure a permanent focus. A shift of 0.001 inch is sufficient to throw the image out of focus. The picture size of the 70 mm. Schmidt camera is 55×55 mm., compared to 63×68 mm. of the Fairchild camera. The picture area of the 35 mm. Schmidt camera is approximately the same as that of the Recordak camera. The principal advantage of cameras of the Schmidt type is their greater speed. The power requirements for

the roentgen-ray generator are thereby lessened, tube life extended, and radiation dosage to the patient reduced. Other roentgen applications in which these cameras may be used include cineroentgenography and photofluorography of such structures as the abdomen, the gastrointestinal tract and the osseous system.

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Publisher: CHARLES C THOMAS, 301-327 East Lawrence Avenue, Springfield, Illinois.

Issued Monthly. Subscription \$10.00 per year, \$11.00 in Canada and \$12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 301-327 East Lawrence Avenue, Springfield, Ill. Information of interest to all readers will be found on page iv.

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EDITORIALS

URETHANE THERAPY

URETHANE is an ethylcarbamate ($C_2H_5OCONH_2$) which is frequently used as an anesthetic in laboratory animals since it produces rapid and profound narcosis. Sometimes it is also employed for human anesthesia, especially in children.

Hawkins and Murphy¹ in 1925 noted that animals subjected to urethane anesthesia often showed changes in the lymphoid system which were strikingly similar to those observed following whole body roentgen irradiation. They also found that if rats, under urethane anesthesia, were given roentgen amounts well under the lethal dose, death invariably resulted within seven to fourteen days after the exposure. Later several authors demonstrated that urethane is a powerful growth-inhibiting agent acting by a change or suppression of the mitosis of the cells. Haddow and Sexton,² in particular, showed that urethane produces a retardation in the growth of mammary carcinoma in mice and a suppression of Walker rat carcinoma 256. In a more recent publication Murphy and Sturm³ reported that rats inoculated with leukemic cells and treated with urethane failed to develop the disease whereas in an inoculated but untreated control group only 16.9 per cent of the animals were resistant. A similar inhibiting effect was discovered for lymphosarcoma.

It was this experimental work on the growth-inhibiting effects of urethane that induced several clinical investigators to try

to use the drug in man for the treatment of leukemia and some other malignant neoplastic diseases characterized by mitosis.

The first report on the results was presented in 1946 by Paterson, Haddow, ApThomas and Watkinson.⁴ These authors treated cases of myeloid and lymphatic leukemia, as well as a few other types of malignant disease. The observations ranged over periods of from five weeks to eleven months. Of 19 cases of myeloid leukemia (18 chronic and 1 acute) 13 received urethane alone and in 6 the urethane was followed by roentgen therapy. All showed a remarkable response, the white cell count often exhibiting a dramatic fall. There was also a rise of the hemoglobin in 10 cases. The grossly enlarged spleen regressed considerably in most instances and in some it became impalpable. The general condition of the patients started to improve immediately and the relatively asymptomatic state continued for a shorter or longer duration. The amount of the urethane given varied a great deal, doses of from 19 to 134 gm. being necessary to produce a fall to about 20,000 white cells over a period of from eleven to thirty-six days. It was found impossible to correlate accurately the dose with body weight or with the rate of diminution of the number of white blood cells. The cases which received subsequent roentgen therapy included some which proved refractory to the urethane, others in which the drug had to be discontinued because of severe nausea, and two terminal cases. Except these latter, all cases showed the usual response to the irradiation.

Of 13 cases of lymphatic leukemia (12

¹ Hawkins, J. A., and Murphy, J. B. The effect of ethyl urethane anesthesia on the acid-base equilibrium and cell contents of the blood. *J. Exper. Med.*, 1925, 42, 609-618.

² Haddow, A., and Sexton, W. A. Influence of carbamic esters (urethanes) on experimental animal tumours. *Nature*, London, 1946, 157, 500-503.

³ Murphy, J. B., and Sturm, E. The inhibiting effect of ethyl urethane on the development of lymphatic leukemia in rats. *Cancer Research*, 1947, 7, 417-420.

⁴ Paterson, Edith, Haddow, A., ApThomas, Inez, and Watkinson, Jean M. Leukaemia treated with urethane compared with deep x-ray therapy. *Lancet*, 1946, 1, 677-682.

chronic and 1 acute), in 9 urethane alone was used and in 4 roentgen therapy was given after a trial of the urethane. On the whole, the response of lymphatic leukemia to urethane was found to be less pronounced and more variable than in myeloid leukemia. The smallest dose given was 8 gm. which reduced a white blood cell count of 48,000 to 7,000 in nine days. At the other extreme, a dose of 300 gm. produced a regression of a white blood cell count of 750,000 to normal after sixty-three days. In the cases which received roentgen therapy following unsuccessful trial of urethane the response was the same as if no urethane were given.

To obtain a direct comparison of the urethane action with that of the roentgen rays, Paterson, Haddow, ApThomas and Watkinson also studied a contrast group consisting of 31 cases of the myeloid type and 14 cases of the lymphatic type of leukemia treated with deep roentgen therapy alone. In the myeloid leukemia the irradiation was applied to the spleen. Two techniques of procedure were used. In one, a dose of 200-500 r was administered weekly over a period of several months, in the other daily doses of 100-200 r were given for shorter periods, not exceeding three weeks. In the lymphatic leukemia the treatment included the spleen as well as the enlarged lymph nodes. The irradiation, here too, was carried out either with doses of 250 r at intervals of a week, or with daily doses of 100-200 r for a period of four to ten days, repeated later when required.

In studying the results, Paterson and her associates arrived at the conclusion that urethane produces effects which are along the same line as those obtained by the usual methods of deep roentgen therapy. As already mentioned, the response was somewhat more pronounced in the myeloid than in the lymphatic type of leukemia. However, although in many cases the palliative effect was quite great, there was no indication from the short period of study that a permanent result may be derived. After a certain interval immature

cells reappeared in the blood and in not a few instances a relapse has developed.

As a side reaction the authors noted nausea in about 50 per cent, vomiting in 25 per cent, and diarrhea in about 10 per cent of the cases treated with urethane. In a few instances these symptoms were sufficiently severe to necessitate the withdrawal of the drug.

Paterson, Haddow, ApThomas and Watkinson also studied the effect of urethane in 13 cases of advanced carcinoma of the breast and in 13 cases of other types of malignant disease. Of these, 9 developed a moderate leukopenia. In one the white blood cell count dropped to 1,200 but returned to normal after the urethane was withdrawn. In regard to its action on the tumor proper, in 3 of the breast cases and in 4 of the miscellaneous group there was a transitory regression in the size of the lesions.

Stimulated by these early results, other investigators prescribed urethane and its derivatives for the treatment of leukemia and of various types of malignant neoplasms. Most of the published reports, however, are preliminary. Although the inhibitory effect of the urethane on growth is generally recognized, proof of a long-range clinical value of the method is lacking. Also, there is an accumulating evidence that the drug is not altogether harmless.

Recently, Berman and Axelrod⁵ reviewed the entire literature on urethane therapy. They were able to collect only 90 cases of malignant neoplastic diseases which were treated by urethane or some closely related compounds. Brief references to some phase of the effect of the drug were made by a number of other writers but within rather restricted limits. To this collected series the authors add 8 cases of their own in which detailed clinical, hematologic and histologic observations were made. The cases include 4 patients with leukemia, one

⁵Berman, L., and Axelrod, A. R. Effect of urethane on malignant diseases; clinical, hematologic and histologic observations on patients with carcinoma, leukemia and related diseases. *Am. J. Clin. Path.*, 1948, 18, 104-120.

with lymphatic leukemic reticuloendotheliosis, one with multiple myeloma, one with mycosis fungoides and one with generalized carcinoma.

An analysis of the ultimate results of the cases collected from the literature shows that there are no claims of permanent cures. Some palliation was noted in carcinomatosis, lymphoblastoma and chiefly in leukemia. The androgen-independent carcinoma of the prostate also exhibited promising improvement. The most important changes in the leukemias were diminution in the size of the spleen, liver and enlarged lymph nodes and a reversion toward a more normal peripheral blood picture. In Berman and Axelrod's cases there was little or no clinical improvement in 3 of 4 patients with leukemia although they exhibited some hematologic responsiveness and there was a diminution in the size of the spleen, liver and enlarged lymph nodes. Two patients died of their disease during the treatment. In the 4 patients with other malignant diseases the general status was poor to begin with and it remained so after treatment.

Of great interest are the hematologic observations made by Berman and Axelrod. It was noted that urethane caused a fall in all leukocytic elements whether or not the initial blood count showed a normal or leukemic pattern. The immature elements are affected to a greater extent than the more differentiated forms. Leukopenia, thrombocytopenia and hypoplastic anemia are toxic effects indicating bone marrow injury which may prove of temporary duration or be permanent. The possibility of hepatocellular damage must also be considered.

Two factors stand out in conjunction with these hematologic changes. The one is that the progressive effect of the urethane may continue after the drug has been withdrawn and the other is the lack of correlation between the amount of urethane given and the extent or rate of change in the peripheral blood or bone marrow pattern. For this reason, repeated blood and

bone marrow studies are required during the entire course of the treatment not only to help in properly evaluating the efficacy of the urethane action but also to safeguard against possible dangerous over-treatment.

That such danger exists has already been observed by Paterson, Haddow, ApThomas and Watkinson. One of their cases of myeloid leukemia died as a result of aplasia of the hematopoietic system and another, in which a marked drop in the white and red blood cells developed after large amounts of urethane had been given over a long time, later recovered following transfusions. It was felt that in both cases the drug was partly responsible for the deleterious effect.

Webster⁶ also noted a fatality in a case of myelogenous leukemia after treatment with urethane. His patient was first treated with roentgen rays. After six months an exacerbation of the disease developed and at this time urethane in daily doses of 3 gm. by mouth, which is now the commonly used dose, was prescribed. There was the usual hematologic response but the drop in the white blood cell count occurred at a somewhat slower rate. After thirty-nine days of medication, or a total dose of 117 gm. of urethane, the patient started to exhibit hemorrhagic phenomena although the blood count showed 24,000 white cells and 80 per cent hemoglobin. The urethane was immediately withdrawn but apparently the blood cell inhibition was already so profound that despite all counter measures fourteen days later the white blood cell count fell to 100 and the patient died with cerebral hemorrhage. On the basis of this observation and after reviewing 3 other cases reported in the literature with deleterious effect due to urethane medication, Webster expresses the opinion that the drug is more toxic in leukemia than previously noted and that therefore its increased use warrants a word of caution.

It is perhaps of more than academic in-

⁶ Webster, J. J. Urethane in leukemia. *J.A.M.A.*, 1947, 135, 901-903.

terest in this respect, especially in considering the life expectancy of the patient, that urethane is a known carcinogenic agent. Nettleship and Henshaw⁷ were able to induce pulmonary tumors in mice with urethane in 1943 and since then several similar articles have appeared in the literature. In 1944 Henshaw and Meyer⁸ reported on the minimal number of anesthetic treatments which are required with urethane to induce the tumors. Later Jaffé⁹ secured pulmonary adenomas in rats both by injection and by feeding. Some of Jaffé's animals also developed tumors in the liver. Recently Guyer and Claus¹⁰ published a report dealing with the induction of lung tumors in rats by means of intraperitoneal injections of urethane. A dose of 1 cc. of a 10 per cent aqueous solution per 100 gm. of body weight was given. Multiple pulmonary adenomatous tumors developed in the majority of 91 rats so treated, including one lot of 28 which had been selectively bred for many years to obtain immunity to carcinoma transplants. The animals became ill eight to ten months after the first injection of urethane and died with rapid weight loss one or two months later. Postmortem examinations revealed numerous tumors beneath the pleura of the lungs with occasional nodules more deeply imbedded in the lung parenchyma but

there was no evidence of tumors elsewhere in the body. Three animals received one single injection and they all developed tumors although not as plentifully as rats receiving multiple injections.

From a study of the cytological effects on various tissues, Guyer and Claus determined that urethane acts by reducing all stages of mitosis for some twelve to sixteen hours. This apparently accounts for the retardation of growth in the malignant neoplasms with the concomitant drop in the white blood cells, especially in the leukemias. Whether the temporary mitotic suppression also plays a role in the initiation of pulmonary tumor formation or is merely an accompanying response to the causative agent remains a problem for further investigation.

All in all, the evidence available at the present time points to the fact that urethane therapy is of limited value. In the leukemias it leads to palliation of shorter or longer duration, but in view of the marked cytotoxic effect a very careful control by repeated hematologic and bone marrow studies is necessary during the entire course of the treatment. In the various types of malignant neoplasms in which it has been tried its merit was found to be rather doubtful. It is perhaps not too speculative to say that the method will not replace radiation therapy or other established procedures in the treatment of either of these conditions. If used in cases with an expected longer survival, the possible carcinogenic effect, especially on the lungs, must also be taken into consideration.

Harper Hospital
Detroit 1, Mich.

T. LEUCUTIA, M.D.

⁷ Nettleship, A., and Henshaw, P. S. Induction of pulmonary tumors in mice with ethyl carbamate (urethane). *J. Nat. Cancer Inst.*, 1943, 4, 309-319.

⁸ Henshaw, P. S., and Meyer, H. L. Minimal number of anesthetic treatments with urethane required to induce pulmonary tumors. *J. Nat. Cancer Inst.*, 1944, 4, 523-525.

⁹ Jaffé, W. G. Carcinogenic action of ethyl urethane on rats. *Cancer Research*, 1947, 7, 107-112.

¹⁰ Guyer, M. F., and Claus, P. E. Tumor of the lung in rats following injections of urethane (ethyl carbamate). *Cancer Research*, 1947, 7, 342-345.





ALBAN KÖHLER
1874—1947

ALBAN KÖHLER, whose death occurred February 26, 1947, was born in Petsa, not far from Altenberg in Thüringen, March 1, 1874. All of his ancestors were farmers, as official records show, as far back as the year 1440. He was given a classical education, in the course of which he showed

exceptional talent in languages, including Italian, Polish, Russian, English and French. He studied medicine at the University of Freiburg and also studied in Erlangen and in Berlin.

At first inclined toward surgery, he was made assistant to Friedrich Kramer in

Wiesbaden in 1899. However, his surgical activities were early associated with medical radiology, to which he immediately gave his major interest. One of his earlier publications appeared in 1901 when he was twenty-seven years of age, "Roentgen Aspects of Osseous Diseases." In 1902 he settled in Wiesbaden, establishing his roentgen-ray equipment and his consulting offices in his home, an arrangement he continued all his life. In 1903 he decided to limit his practice to roentgenology, thus becoming one of the earliest physicians to so dedicate himself. His industry and keen interest in radiology early showed results in two more books: "Hip Joint and Femur in the Roentgen Picture" and "Roentgen Diagnosis of Tuberculous Adenitis in Children."

The German Röntgen Society, which was organized in 1905, recorded Alban Köhler as one of its founders and in 1912 its president. He was later elected to honorary membership and awarded the Society's gold medal.

The chief accomplishment of Alban Köhler, however, was the publication in 1910 of his book entitled "The Limits of the Normal and the Beginnings of the Pathological in Roentgenology," a book which has gone through eight editions and whose ninth edition was in process of publication until interrupted by aerial bombardment and fire during the war. In each of these new editions Köhler worked indefatigably to keep it revised thoroughly up-to-date. Perhaps more than any other single thing, this book of Köhler's which has been translated into many languages, has contributed potently to the widespread fame of German science.

Thirteen foreign medical and roentgen societies elected him as an honorary or corresponding member, largely on the basis of this book which has appropriately been called the "Radiologist's Bible." He was also an honorary fellow of the American College of Radiology; corresponding member of the American Roentgen Ray Society,

and a life member of the British Institute of Radiology.

Dr. Köhler never had any teaching connection with universities. He practiced as a radiological specialist in Wiesbaden, rejecting invitations to various high administrative positions in big clinics or hospitals. These prospects never allured him. He did nearly everything by himself; later on he had an occasional volunteer assistant and then a laboratory technician. His faithful wife helped him in his office until her death in 1942. The simplest roentgenological operation he accomplished often more easily than did many other roentgenologists with more modern devices, which were more costly than could be afforded by a private practice.

He was lucky enough to escape any severe roentgen-ray damage, although he himself exposed and developed nearly all of his plates and films for forty years. He used fluoroscopy very little, especially in the earlier years, and thereby was lucky enough to be spared any roentgen-ray damage.

His last days were unhappy. His wife was taken from him in 1942 and in 1945 his only son fell on the Western Front. Just before that, Wiesbaden was bombed in a very severe air attack, and in connection with this bombardment he had the misfortune to lose by fire not only his home but also his large roentgen institute which was incorporated with it. His loss also included his historical library, one of the outstanding radiological libraries of the world. He also lost the notes and illustrations of the ninth edition of his well known book, although the first 250 pages had already been printed before the publisher's plant in Leipzig was bombed out.

Toward the last he renewed contacts with many of his friends in the United States and was grateful to them for their generous response to his call.

Köhler pioneered in many roentgen activities. His earlier publications have already been mentioned, but in addition he

pioneered in teleroentgenography, the localization of foreign bodies in the eye, stereoroentgenography of the chest; cinematography of the respiratory tract (1907); the observation of calcific plaques in the aortic arch, and numerous other phases of roentgen diagnosis. His name has been given to two diseases: osteochondritis os

navicularis pedis and osteochondritis of the second metatarsophalangeal joint. He was one of the early users of filters in roentgen therapy. There is no doubt that his influence will long continue among radiologists in all lands.

JAMES T. CASE, M.D.





WESTON A. PRICE, D.D.S.
1870—1948

WESTON A. PRICE, D.D.S., formerly of Cleveland, Ohio, died January 23, 1948, at Santa Monica, California, where he had lived since retiring from active practice in 1943. Dr. Price had been a charter member of the American Roentgen Ray Society and secretary of the Society in 1901. Born in 1870, in Newburgh, Ontario,

he studied at the Collegiate Institute, Naponee, Ontario, and received the degree of Doctor of Dental Surgery from the University of Michigan in 1893. Thereafter he practiced his profession in Cleveland for fifty years.

Dr. Price was an eminent scientist. He probably was the first, in this country at

least, to employ dental roentgenography in practice. He published many articles on the subject, the first appearing in Transactions of the American Roentgen Ray Society in 1904, entitled "Technique Necessary for making Good Dental Skiagraphs." Other early articles dealt with dental infections in relation to diseases, cataphoresis, and desensitization of teeth, and the first pyrometer furnace which he invented for baking porcelain. The principal interest to which he devoted his active life was investigation of the influences of nutrition, especially calcium metabolism, on the development of the teeth. He traveled to remote parts of the earth to study the influence of dietary habits on the dental characteristics of primitive peoples. These investigations resulted in a valuable collection of photographs of these dental characteristics, which he presented to the American Academy of Applied Nutrition.

Dr. Price had been president of the Cleveland Dental Society, Ohio State Dental Society, Northern Ohio Dental Association, a Fellow of the American Association for the Advancement of Science, a member of the American Dental Association, American Association of Applied Science, the American Association of Physical Anthropologists, the Biological Society of Great Britain, and the International Association for Dental Research.

The accomplishments in original researches and participation in scientific societies in which he was active reveal the inherent attributes of Dr. Price. In addition he was well loved by his patients and respected in the community. It is not trite but a truism to state that he was a "scholar and a gentleman." The American Roentgen Ray Society is proud that he was a member.

U. V. PORTMANN, M.D.



SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY

Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Palmer House, Chicago, Ill., Sept. 14-17, 1948.

AMERICAN RADIUM SOCIETY

Secretary, Dr. H. F. Hare, 605 Commonwealth Ave., Boston, Mass. Annual meeting: Stevens Hotel, Chicago, Ill., June 20-22, 1948.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1948, to be announced.

AMERICAN COLLEGE OF RADIOLOGY

Secretary, Mac F. Cahal, 20 N. Wacker Drive, Chicago 6. Annual meeting: Continental Hotel, Chicago, Ill., June 20, 1948.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION

Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: Chicago, Ill., June 21-25, 1948.

ALABAMA RADIOLOGICAL SOCIETY

Secretary, Dr. C. S. Stickley, 515 Bell Bldg., Montgomery, Ala. Next meeting time and place of Alabama State Medical Association.

ARKANSAS RADIOLOGICAL SOCIETY

Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

BROOKLYN ROENTGEN RAY SOCIETY

Secretary, Dr. A. H. Levy, 1354 Carroll St., Brooklyn 13, N. Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY

Secretary, Dr. Mario C. Gian, 610 Niagara St., Buffalo, N. Y. Meets second Monday evening each month, October to May inclusive.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY

Secretary, Dr. Dwight V. Needham, 608 E. Genesee St., Syracuse, N. Y. Three meetings a year. January, May, November.

CHICAGO ROENTGEN SOCIETY

Secretary, Dr. T. J. Wachowski, 310 Ellis Ave., Wheaton, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY

Secretary, Dr. Eugene L. Saenger, 735 Doctors Bldg., Cincinnati 2, Ohio. Meets last Monday of each month, September to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY

Secretary, Dr. George L. Sackett, 10515 Carnegie Ave. Cleveland 6, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

DALLAS-FORT WORTH ROENTGEN STUDY CLUB

Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

DENVER RADIOLOGICAL CLUB

Secretary, Dr. Mark S. Donovan, 306 Majestic Bldg., Denver 2, Colo. Meets third Friday of each month at Department of Radiology, Colorado School of Medicine.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY

Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA RADIOLOGICAL SOCIETY

Secretary, Dr. J. A. Beals, St. Luke's Hospital, Jacksonville, Fla. Meets twice yearly, in April preceding annual meeting of Florida Medical Society, and in November.

GEORGIA RADIOLOGICAL SOCIETY

Secretary, Dr. Robert Drane, DeRenne Apartments, Savannah, Ga. Meets in mid-winter and at annual meeting of Medical Association of Georgia in the spring.

HOUSTON X-RAY CLUB

Secretary, Dr. Curtis H. Burge, 3020 San Jacinto St., Houston 4, Texas. Meetings fourth Monday of each month.

RADIOLOGICAL SOCIETY OF KANSAS CITY

Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

ILLINOIS RADIOLOGICAL SOCIETY

Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY

Secretary, Dr. J. A. Campbell, Indiana University Hospitals, Indianapolis 7. Meets second Sunday in May.

IOWA X-RAY CLUB

Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

KENTUCKY RADIOLOGICAL SOCIETY

Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY

Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOS ANGELES RADIOLOGICAL SOCIETY

Secretary, Dr. Moris Horwitz, 441 No. Camden Drive, Beverly Hills, Calif. Meets second Wednesday each month at Los Angeles County Medical Assn. Building.

LOUISIANA RADIOLOGICAL SOCIETY

Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

LOUISVILLE RADIOLOGICAL SOCIETY

Secretary, Dr. E. L. Pirkey, Louisville General Hospital, Louisville 2, Ky. Meets monthly on second Friday at Louisville General Hospital.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS

Secretary, Dr. R. D. McDuff, 220 Genesee Bank Bldg., Flint 3, Mich.

MILWAUKEE ROENTGEN RAY SOCIETY

Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

* Secretaries of societies not here listed are requested to send the necessary information to the Editor.

MINNESOTA RADIOLOGICAL SOCIETY

Secretary, Dr. Chauncey N. Borman, 802 Medical Arts Bldg., Minneapolis 2, Minn. Two meetings yearly, one at time of Minnesota State Medical Association the other in the fall.

NEBRASKA RADIOLOGICAL SOCIETY

Secretary, Dr. Ralph C. Moore, Nebraska Methodist Hospital, Omaha 3, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

NEW HAMPSHIRE ROENTGEN RAY SOCIETY

Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

NEW YORK ROENTGEN SOCIETY

Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

NORTH CAROLINA RADIOLOGICAL SOCIETY

Secretary, Dr. J. E. Hemphill, 323 Professional Bldg., Charlotte 2, N. C. Meets in May and October.

NORTH DAKOTA RADIOLOGICAL SOCIETY

Secretary, Dr. C. O. Heilman, 807 Broadway, Fargo. Meetings held by announcement.

OHIO STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Carroll C. Dundon, 2065 Adelbert Road, Cleveland 6, Ohio. Next meeting at annual meeting of Ohio State Medical Association, Cincinnati, Ohio, March 31, 1948.

OKLAHOMA STATE RADIOLOGICAL SOCIETY

Secretary, Dr. P. E. Russo, 230 Osler Bldg., Oklahoma City, Okla. Three regular meetings annually.

OREGON RADIOLOGICAL SOCIETY

Secretary, Dr. William Y. Burton, 242 Medical Arts Bldg., Portland 5, Oregon. Meets monthly 2nd Wednesday, 8:00 P.M., Library of University of Oregon Medical School.

ORLEANS PARISH RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY

Secretary, Dr. S. J. Hawley, 1320 Madison St., Seattle 4, Wash. Meets annually in May.

PACIFIC ROENTGEN SOCIETY

Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY

Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport. Annual meeting, May 21-22, 1948, Erie, Pa., at Hotel Lawrence.

PHILADELPHIA ROENTGEN RAY SOCIETY

Secretary, Dr. Arthur Finkelstein, Graduate Hospital, 19th and Lombard St. Meets first Thursday each month October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY

Secretary, Dr. R. P. Meader, 4002 Jenkins Arcade Pittsburgh 22, Pa. Meets 6:30 P.M. at Webster Hall Hotel on second Wednesday each month, October to May inclusive.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY

Secretary, Dr. Harry A. Miller, 2452 Eutaw Place, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY

Secretary, Dr. Robert M. Lowman, Grace-New Haven Community Hospital, New Haven 11, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION

Secretary, Dr. Roy G. Giles, Temple, Texas.

RADIOLOGICAL SOCIETY OF NEW JERSEY

Secretary, Dr. Raphael Pomeranz, 31 Lincoln Park, Newark, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.

Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

Secretary, Dr. Maurice D. Frazer, 1037 Stuart Bldg., Lincoln, Nebr. Meets in Salt Lake City, Utah, 1948.

ST. LOUIS SOCIETY OF RADIOLOGISTS

Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September.

SAN DIEGO ROENTGEN SOCIETY

Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly, first Wednesday at dinner.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION

Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY

Secretary, Dr. John H. Gilmore, 720 N. Michigan Ave., Chicago 11, Ill.

SHREVEPORT RADIOLOGICAL CLUB

Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

SOUTH CAROLINA X-RAY SOCIETY

Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY

Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY

Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING

Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE

Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May inclusive. Room 203, Service Memorial Institute, 426 N. Charter St., Madison.

UTAH RADIOLOGICAL CONFERENCE

Secretary, Dr. Henry H. Lerner, School of Medicine, University of Utah, Salt Lake City 1. Meets 1st and 3rd Thursdays monthly from 7:30 to 10 P.M., Salt Lake County General Hospital, September to June.

UTAH STATE RADIOLOGICAL SOCIETY

Secretary, Dr. M. Lowry Allen, Judge Bldg., Salt Lake City 1, Utah. Meets third Wednesday in September, November, January, March and May.

VIRGINIA RADIOLOGICAL SOCIETY

Secretary, Dr. P. B. Parsons, Norfolk General Hospital, Norfolk, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Homer V. Hartzell, 310 Stimson Bldg., Seattle 1, Wash. Meets fourth Monday each month, October through May, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO

Secretary, Dr. Ivan J. Miller, 2000 Van Ness Ave. Meets monthly on third Thursday at 7:45 P.M., first six months of year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

CUBA**SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA**

President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

MEXICO**SOCIEDAD MEXICANA DE RADIOLOGIA Y FISIOTERAPIA**

General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

BRITISH EMPIRE**BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE ROENTGEN SOCIETY**

Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

FACULTY OF RADIOLOGISTS

Secretary, Dr. M. H. Jupe, 23 Welbeck St., London, W.1 England.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)

Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London.

CANADIAN ASSOCIATION OF RADIOLOGISTS

Honorary Secretary, Dr. E. M. Crawford, 2100 Marlowe Ave., Montreal 28, Que. Meetings January and June.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION

Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

SOCIÉTÉ CANADIENNE-FRANÇAISE D'ELECTROLOGIE ET DE RADIOLOGIE MÉDICALES

Secretary, Dr. Origène Dufresne, 4120 Ontario St., East, Montreal, P. Q.

AUSTRALIAN AND NEW ZEALAND ASSOCIATION OF RADIOLOGISTS

Honorary Secretary, Dr. Alan R. Colwell, 135 Macquarie St., Sydney, N.S.W.

Honorary Secretaries, State Branches:

New South Wales, Dr. E. W. Frecker, 135 Macquarie St., Sydney.

Victoria, Dr. T. L. Tyrer, 3 Lockerbie Court, East St. Kilda.

Queensland, Dr. J. Adam, 131 Wickham Terrace, Brisbane.

South Australia, Dr. B. C. Smeaton, 178 North Terrace, Adelaide.

Western Australia, Dr. A. M. Nelson, 179-B St. Georges Terrace, Perth.

New Zealand, Dr. E. G. Lynch, 12 Bolton St., Wellington.

SOUTH AMERICA**SOCIEDAD ARGENTINA DE RADIOLOGIA**

Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

SOCIEDADE BRASILEIRA DE RADIOLOGIA MEDICA

Secretary, Dr. Nicola Caminha, Av. Mem de Sa, Rio de Janeiro, Brazil. Meets monthly, except during January, February and March.

SOCIEDADE BRASILEIRA DE RADIOTERAPIA

Secretary, Dr. Andreilino Amaral, Av. Brigadeiro Luiz Antonio, 644, São Paulo, Brazil. Meets monthly on second Tuesday at 9 P.M. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

SOCIEDAD PERUANA DE RADIOLOGIA

Secretary, Dr. Julio Bedoya Paredes, Apartado, 2306 Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

CONTINENTAL EUROPE**SOCIÉTÉ BELGE DE RADIOLOGIE**

General Secretary, Dr. S. Masy, 111 Avenue des Alliés, Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.

ČESKOSLOVENSKÁ SPOLEČNOST PRO RÖNTGENOLOGII A RADIOLOGII V PRAZE

Secretary, Dr. Roman Bláha, Praha XII, stát. nemocnice, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.

POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. L. Zgliczynski, 59 Nowogrodzka St., Warsaw, Poland. Next meeting May 13 and 14, 1948.

GDANSK SECTION, POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. A. Smigielska, Akademia Lekarska, Gdansk. Meets monthly last Sunday at 10.30, X-Ray Dept., Akademia Gdansk.

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Secretary, Dr. L. Zgliczynski, 59 Nowogrodzka St., Warsaw, Poland. Meets monthly.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE

Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 39, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD.

USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY

Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY

Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES

The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA

Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT (SOCIÉTÉ SUISSE DE RADIOLOGIE)

President, Dr. H. E. Walther, Gloristr. 14, Zürich, Switzerland. Annual meeting, on the Bürgenstock, near Lucerne, May 22 and 23, 1948.

AMERICAN RADIUM SOCIETY

A program of unusual interest is promised for the annual meeting of the American Radium Society for June 20, 21 and 22, 1948, Hotel Stevens, Chicago, Illinois. The Program Committee has invited a number of foreign guests who will report on recent advances in European radiotherapy, which information was inaccessible to Americans during the war years. The following have already promised to present reports on Radium and Roentgen Treatment of Cancer: Francois Baclesse and Juliette Band of the Curie Foundation, Paris, the former in charge of roentgen therapy, the latter of radium therapy; Elis Berven, Professor of Radiotherapy at the University of Stockholm and Director of Radiumhemmet; Sir Stanford Cade of London, who has written a most informative book on Radium and Cancer; Brian Windeyer, Professor of Radiotherapy at the University of London, and Director of the Meyerstein Institute of Radiotherapy of the Middlesex Hospital, London; Constance Wood, Director of the Radiotherapeutic Research Unit of the British Medical Research Council, in charge of Radium Beam; Dr. R. McWhirter, Director of Radiology, Royal Infirmary, Edinburgh, Scotland, who has treated twenty-five hundred patients with cancer of the breast with local mastectomy and post-operative roentgen treatment.

A number of equally eminent American Radiotherapists will also participate. An oration on the Discovery of Radium will be given by Dr. Edith H. Quimby at the banquet. The Janeway Lecture, Monday afternoon, on the "Achievement of Radium in the Fight against Cancer," will be given by Sir Stanford Cade. Panel discussions on the treatment of cancer of the tongue, cancer of the breast and "Should Radiotherapy be Separated from Roentgen Diagnosis" and separate papers will be given Monday and Tuesday. Special Refresher Courses will be given by the foreign guests Sunday morning preceding the regular sessions.

Those interested will find it advantageous to write to Stevens Hotel, Chicago, Illinois, for reservations immediately and to Dr. Maurice Lenz, Chairman, Program Committee, 840 Park Avenue, New York 21, New York, for further information regarding the Refresher Courses.

MID-WEST RADIOLOGIC CONFERENCE

The eighth annual Mid-West Radiologic Conference was held in Milwaukee, Wisconsin, at the Hotel Schroeder on February 6 and 7, 1948. The meeting was sponsored by the Milwaukee Roentgen Ray Society. The attendance was excellent and many interesting subjects were discussed by the speakers.

On Friday, February 6, the following papers were given. Except where noted otherwise the speakers were from Milwaukee.

Address of Welcome. J. C. Griffith, M.D., President, Medical Society of Milwaukee County.

The Collapse Therapy of Pulmonary Tuberculosis from a Roentgenological Standpoint. John D. Steele, M.D.

Diagnostic and Therapeutic Aspect of Tumors of the Hypophyseal Region. Joseph Mufson, M.D.

The Effect of Splenic Irradiation on the Vascular Lesions in Purpura. Frederick W. Madison, M.D.

The Treatment of Leukemia and Other Blood Disorders with Urethane. John S. Hirschboeck, M.D.

Congenital Cardiac Lesions simulating Tetralogy of Fallot. Francis F. Rosenbaum, M.D.

The Importance of Cholangiograms in Common Duct Surgery. Carl W. Eberbach, M.D.

Cardiac Roentgenology in Patients over Forty. J. Edwin Habbe, M.D.

Etiology and Pathogenesis of Prolapsed Gastric Mucosa into the Duodenum. A. Melamed, M.D.

Intussusception in Children. Arthur Schaefer, M.D., and John L. Armbruster, M.D.

Diagnosis of Malignancies by Smear Technique. Leander J. Van Hecke, M.D.

The Excretory Urogram as a Test of Renal Function. James C. Sargent, M.D.

Diagnosis of Small Esophageal Hiatus Hernias. S. Archibald Morton, M.D.

The Production of High Energy Electron Beams and Their Possible Use in Medical Therapy. Jack T. Wilson, Ph.D.

Diagnostic and Therapeutic Aspects of Tumors of the Testicle. S. B. Pessin, M.D., and Irving I. Cowan, M.D.

Diagnostic Problems of the Esophagus. Gerhard D. Strauss, M.D.

Radiation Therapy Problem Clinic. Irving I. Cowan, M.D., R. R. Newell, M.D., San Francisco, California, and Ernst A. Pohle, M.D., Madison, Wisconsin.

On Friday evening a banquet was held at which the guest speaker was Dr. R. R. Newell, Professor of Radiology, Stanford University School of Medicine, San Francisco, California. His subject was "Doctors' Duties and Opportunities in the New Age of Atomic Energy."

On Saturday morning, February 7, there was a Symposium and Round Table Discussion of "Fractures in Children." This was participated in by the following:

Fractures of the Humerus and Forearm in Children. Walter P. Blount, M.D.

Fractures of the Lower Extremity in Children. Albert C. Schmidt, M.D.

Fractures of the Elbow in Children. Irwin Schulz, M.D.

The meeting closed with a Film Study Session with S. A. Morton, M.D., Moderator, Hans Hefke, M.D., Theodore Pfeffer, M.D., and L. W. Paul, M.D., Madison, Wisconsin.

AMERICAN BOARD OF RADIOLOGY

Heretofore the American Board of Radiology has demanded that all candidates admitted to examination should be graduates of an approved Class A medical school. The Board has recently ruled, however, that those who have graduated from foreign and sub-standard medical schools before 1947 may be admitted to the examination if and when they have complied with the other requirements of the Board. No candidate who graduates from a sub-standard school (foreign or domestic) after 1947 will be admitted to the examination.

The Board has also ruled that a maximum credit of six months toward the required three years' training may be allowed for formal didactic courses in the basic sciences.

Many candidates who have applied for the entire field of Radiology or Roentgenology and who pass the examination in Diagnostic Roentgenology or possibly the Therapy part of the examination, ask for a limited certificate in the field in which they have passed, expecting to re-apply shortly for the other field. This they are entitled to do but in order to discourage candidates taking partial certificates the Board has ruled that two years must elapse after a candidate accepts a certificate in one field before he may apply for additional certification.

B. R. KIRKLIN, M.D.

Secretary-Treasurer

American Board of Radiology



DEPARTMENT OF TECHNIQUE

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Charleston, S. C.

SPECIAL PROJECTIONS FOR THE CORACOID PROCESS AND CLAVICLE

By KAETHE FENGLER

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NEW YORK, NEW YORK

THE purpose of presenting the following three cases is to emphasize the importance of employing special projections for the coracoid process of the scapula (Cases I and II) and for the clavicle (Case III). Each of these special positions is equally effective in avoiding overlapping of the coracoid process and demonstrating the clavicle free of rib shadows. In the standard positions the existing lesions in the cases presented here are either barely visible or are inadequately demonstrated.

CORACOID PROCESS

Special projections for the coracoid process were described in several textbooks early in the century but in only a few of the more recent ones.^{1,2,4,5} The degree of central ray angulation recommended varies con-

siderably. It is felt, however, that the angulation required for an adequate dem-



FIG. 1. Conventional roentgenogram of affected shoulder

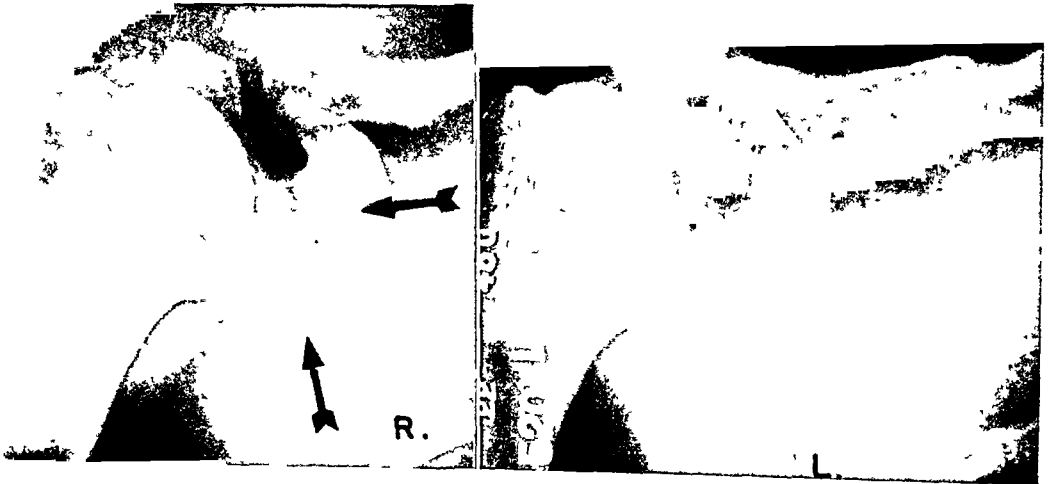


FIG. 2. Special projection for the coracoid process. Right shoulder metastatic lesion. Left shoulder normal for comparison.

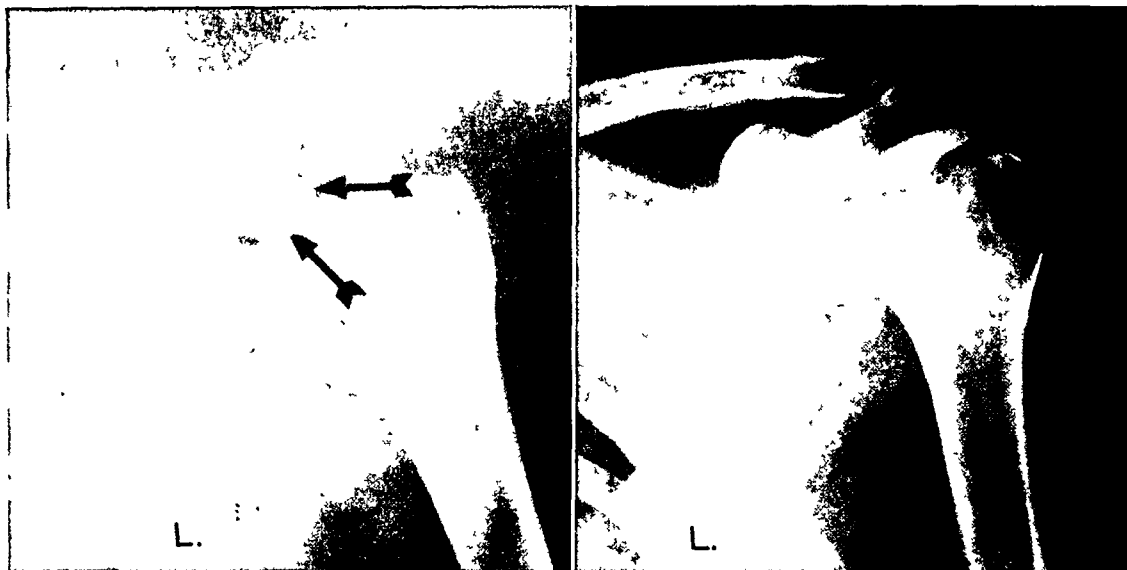


FIG. 3. Tuberculosis of coracoid process. Conventional anteroposterior view on the right shows destructive lesion hidden by adjacent bones. Special coracoid view on the left shows lesion free of superimposed shadows.

onstration in each individual case depends entirely upon the degree of dorsal kyphosis. The sway-backed subject due to the fact that his shoulder will be flat on the table will require an average central ray angulation of from 15° – 20° toward the head. The round-shouldered subject will require an average angulation of from 30° – 35° .



FIG. 4. Special coracoid view of normal shoulder for comparison.

PROCEDURE

Posture

Patient supine.

Center affected coracoid process to midline of the Bucky.

Elevate the opposite shoulder enough to place scapula parallel with plane of film. Abduct the arm slightly, supinate and immobilize the hand.

Central ray

Direct central ray to affected coracoid process at an average angle of from 20° – 30° toward the head.

Film position

Adjust position of cassette so that the mid-point of film coincides with the central ray.

Respiration

Suspend respiration at end of exhalation.

CASE I. N. L.

Request

Right shoulder.

Clinical diagnosis

Subdeltoid bursitis.

Positions

(a) Anteroposterior conventional.

(b) Special projection—anteroposterior, 25° central ray angulation toward head.

Technique

65 kv., 50 ma-sec., 36 inch distance. Bucky diaphragm.



FIG. 5. Conventional view of the shoulder on the left, showing fractured clavicle. The base of the coracoid is obscured by the superimposed acromion. On the right, special posteroanterior view of clavicle also reveals clearly fracture of coracoid.

Roentgenological findings

Large area of rarefaction with poorly defined borders situated in the upper portion of the glenoid process and neck of the scapula extending into the base of the coracoid process.

Roentgenological diagnosis

Metastatic neoplastic process.

Pathology

Curettage of neck of right scapula.

Pathological report No 88723—Malignant tumor, probably metastatic.

Clinical diagnosis

Tuberculous bursitis.

Positions

(a) Anteroposterior conventional.

(b) Special projection—anteroposterior, 30° central ray angulation toward head.

Technique

70 kv., 50 ma-sec., 36 inch distance. Bucky diaphragm.

Roentgenological findings

Destructive lesion involving the tip of the left coracoid process.

Roentgenological diagnosis

Tuberculous osteitis.

Aspiration biopsy

Tuberculosis.

CASE II. S. P.

Request

Left shoulder.

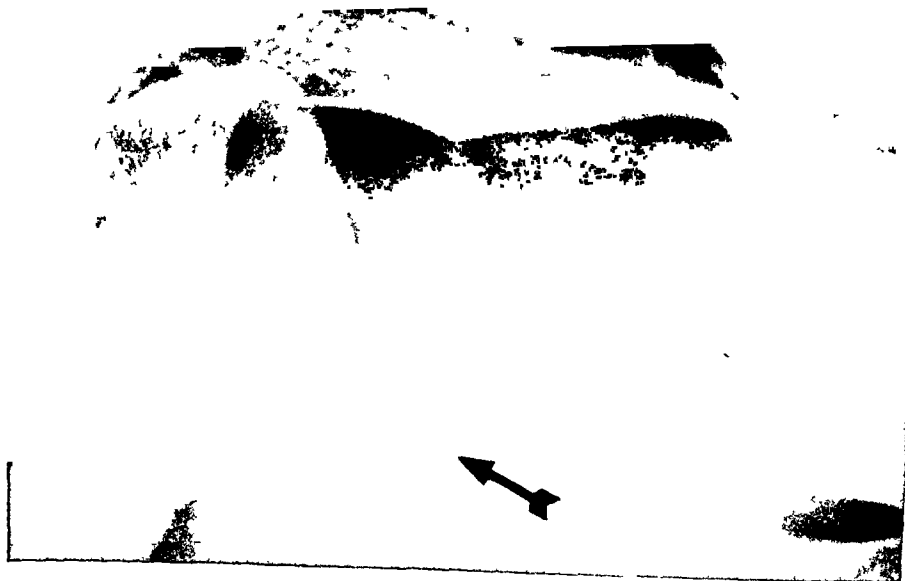


FIG. 6. Special posteroanterior view of clavicle which also shows fractures of clavicle and coracoid (process) clearly.

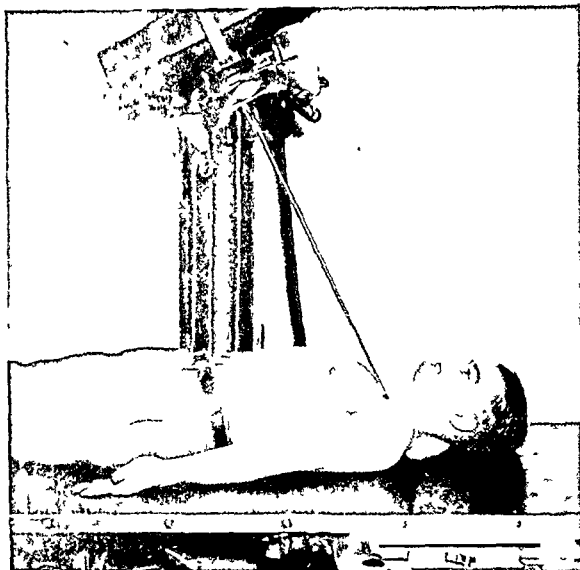


FIG. 7. Photographic demonstration of the special anteroposterior projection for the coracoid process.

CLAVICLE

The most commonly used projections for the clavicle are the posteroanterior view and the anteroposterior infrasupeior view. However, it is felt that a special projection, one of the two recommended by Quesada,³ is advisable. The patient remains in the posteroanterior position throughout the examination.

PROCEDURE

Posture

Posteroanterior, preferably erect for the patient's comfort, or recumbent. Center the clavicle to the midline of the Bucky, arms alongside of body. Turn the face away from the affected side to prevent superimposition on the clavicle.

Central ray

Direct central ray to mid-point of clavicle at an angle of 45° toward feet.

Film position

Adjust cassette so that mid-point of film will coincide with central ray.

Respiration

Suspend respiration at the end of exhalation.

Technique

70 kv., 50 ma-sec., 36 inch distance. Bucky diaphragm.

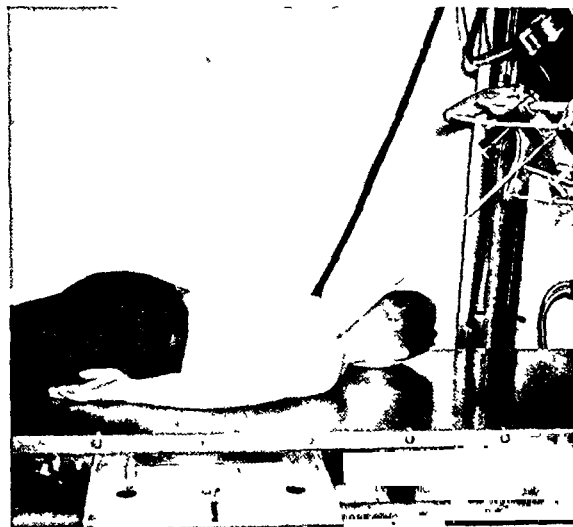


FIG. 8. Photographic demonstration of the special posteroanterior projection for clavicle and coracoid process.

CASE III.

Request

Left shoulder.

Clinical diagnosis

- (a) Fracture of clavicle and
- (b) humerus.

Positions

- (1) Posteroanterior conventional.
- (2) Special projection—posteroanterior, 45° central ray angulation toward feet.

Technique

70 kv., 50 ma-sec., 36 inch distance. Bucky diaphragm.

Roentgenological findings

- (1) Fracture of clavicle.
- (2) Fracture of coracoid process.

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REFERENCES

1. Military Roentgenology. War Department Technical Manual. T. M. 8-280. Supt. of Doc., Govern. Print. Off., Washington, D. C., 1944.
2. Outline of Modern X-Ray Technique. Third edition. Picker X-Ray Corporation, New York, 1941.
3. QUESADA, F. Technique for roentgen diagnosis of fractures of clavicle. *Surg., Gynec. & Obst.*, 1926, 42, 424-428.
4. RHINEHART, D. A. Roentgenographic Technique. Third edition. Lea & Febiger, Philadelphia, 1943.
5. SANTE, L. R. Manual of Roentgenological Technique. Tenth edition. Edwards Bros., Inc., Ann Arbor, Michigan, 1943. (Eleventh edition 1944, p. 85).

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

LYSHOLM, ERIK. Experiences in ventriculography of tumours below the tentorium. *Brit. J. Radiol.*, Nov., 1946, 19, 437-452.

This paper was read as the Mackenzie Davidson Memorial Lecture before the British Institute of Radiology. The author discusses the 467 subtentorial lesions which were seen during a period of fifteen years and which were investigated by ventriculography. The lesions encountered included aqueduct stenosis, arachnoiditis, and tumors of the corpora quadrigemina, pons, cerebellopontine angle, suprafastigial and infrafastigial portions of the vermis, and cerebellar hemispheres. Most of the diagnoses were verified and in many of the cases presented, the ventriculographic and gross pathological findings are depicted together.

Localization of tumors of the quadrigeminal plate was accurate in slightly more than half of the cases. Of 58 vermis tumors there was accurate localization possible in 49. In cerebellar hemisphere tumors it was possible to locate the lesion exactly in 71 of 75 cases.

The paper consists mainly of illustrations with line drawings for explanation. The various lesions are all well shown, and an explanatory note concerning the ventriculographic and pathologic findings is given with each. Since the important part of the article is its illustrations, it should be seen.—*E. F. Lang.*

NECK AND CHEST

PEIRCE, CARLETON B., CRUTCHLOW, EVERETT F., HENDERSON, ARTHUR T., and MCKAY, JOSEPH W. Transient focal pulmonary edema. *Am. Rev. Tuberc.*, July, 1945, 52, 1-14.

The authors make a complete review of the literature on Löffler's syndrome and report 8 cases. It is concluded that the evanescent and variable areas of increased pulmonary density are focal zones of transient pulmonary edema probably associated with the allergic state; they are a local manifestation of the individual's response to an allergen elsewhere, not an inflammatory nodule nor a more general reaction.

In the authors' cases the eosinophilia and roentgenographic pulmonary involvement were out of all proportion to the clinical evidence of the disease.

A note of warning is sounded that care be exercised to ensure that no such cases be stigmatized with the diagnosis of tuberculosis or tuberculosis suspect on one roentgenographic observation. Careful clinical history and physical examination are still required for diagnosis.—*James J. McCort.*

GROSSMANN, MARIA E. Pulmonary oil embolism. *Brit. J. Radiol.*, May, 1946, 19, 178-180.

Pulmonary embolism is fortunately a rare complication, following uterosalpingography. Several cases of oil embolism have been reported prior to this paper. Fatal cases have also been reported following the injection of oil into the urinary bladder and urethra. An interesting case of pulmonary and cerebral embolism has been described by Hemmeler (1939). He demonstrated fine oil droplets in the lungs two days after the injection.

The author describes 2 more cases of massive pulmonary embolism following investigation for sterility. Chest films in both cases demonstrated tiny sharply defined dense opacities, scattered over both lung fields with a fine reticular distribution. Dense linear and V-shaped opacities were attributed to opaque oil embolism of the pulmonary arteries, arterioles, and capillaries. The roentgen appearance in both cases is comparable to Walther's experimental findings produced by injecting 1 cc. of 40 per cent lipiodol into the ear vein of a rabbit.—*K. K. Latteier.*

LOEWENSTEIN, ERNST. Congenital tuberculosis; its clinical importance. *Am. Rev. Tuberc.*, March, 1945, 51, 225-230.

1. Congenital infection occurs from the placenta and therefore not earlier than the 4th month of pregnancy. Germinal infection plays no role. Infection by aspiration or ingestion of amniotic fluid is rare.

2. Placental tuberculosis is far more frequent

than is generally known, even in cases with very small lesions in the lungs.

3. Congenital foci, especially in the liver may heal spontaneously.

4. Blood from the umbilical cord contained tubercle bacilli in 3 babies whose mothers had rheumatic endocarditis; all 3 babies stayed well. Bacilli were found in the blood from the umbilical cord of 9 cases out of 59 tuberculous mothers; 1 baby died of miliary tuberculosis. Positive umbilical cord blood was found in 2 out of 210 apparently healthy mothers; the 2 babies remained well.

5. Therefore, the prognosis of congenital tuberculosis is not absolutely hopeless, especially when the blood invasion occurs only during delivery.—*James J. McCort.*

REISNER, DAVID, and DOWNES, JEAN. Minimal tuberculous lesions of the lung. *Am. Rev. Tuberc.*, May, 1945, 51, 393-412.

This is a study of the clinical significance of the tuberculous lesion of the lung of minimal extent. It is based on a study of 469 cases, the majority of which were observed for a period of five years or longer. The classification "minimal tuberculosis" includes lesions of diverse types, ranging from those of an apparently recent origin through those showing various gradations of healing, to lesions of an obviously old and obsolete type. The majority of the patients showing involvement of minimal extent are asymptomatic and aside from the roentgenological findings present few objective criteria for evaluation of their clinical significance.

The character of the lesion at the time of initial diagnosis was found to be closely related to the behavior of the lesion and risk of progressive disease. Lesions of the exudative or exudative-productive type are characterized by an unstable behavior and a distinct tending to progression. Progression was observed in about one-half of the white patients and in 61 per cent of the non-whites. On the other hand, lesions classified as of productive-fibrotic or fibrocalcific character have shown a stationary behavior in the majority of instances, progression or instability having occurred in only 5 per cent of the white and in 14 per cent of the non-white patients. Lesions of the fibrocalcific type showed the highest rate of stability, progression being a rather exceptional occurrence in this type of involvement.—*James J. McCort.*

LONG, ESMOND R., Tuberculosis as a military problem. *Am. Rev. Tuberc.*, June, 1945, 51, 489-504.

Exclusion of tuberculosis from military service under current conditions is dependent on rapid, mass roentgen-ray methods. Cases developing in the United States Army in World War II for the most part represent extension from small areas of infiltrative tuberculosis not previously detected. Extension from scarred and calcified primary lesions has not been demonstrated. The author who served as consultant for tuberculosis to the Surgeon General states that the total admission and discharge rates in our Army in World War II are approximately one-tenth of those prevailing in World War I.

The predominant type of tuberculosis occurring in our army was the chronic ulcerative, pulmonary form. Acute forms were relatively rare, at least in the white race and indications were not evident that climate or any specific environment is a factor in the development of fulminating disease.—*James J. McCort.*

CHRISTIE, A., and PETERSON, J. C. Histoplasmin sensitivity. *J. Pediat.*, Oct., 1946, 29, 417-432.

The authors have shown in previous studies that there was a definite correlation between histoplasmin sensitivity and lung calcifications. They also, together with other investigators, have found a marked geographical variation in the prevalence of pulmonary calcifications and histoplasmin sensitivity. The present study which elaborates on the previous ones is based on three groups: (1) 181 children from an institute for the care of children in Middle Tennessee aged from 2-19 years and 315 children from a Tennessee industrial school drawing from the whole state of Tennessee and ranging in age from 6-19 years; (2) 1,255 students from Vanderbilt University approximately 50 per cent of whom were natives of Tennessee, and (3) 381 patients from Vanderbilt University Hospital, mostly residents from Middle Tennessee. Both the highest and lowest economic groups were represented.

Of the three groups a total of 1,107 cases had chest roentgenograms and tuberculin and histoplasmin skin tests. Sixty-two per cent of the Tennessee residents who were sensitive to histoplasmin and not to tuberculin had pulmonary calcifications and only 42 per cent who were

tuberculin sensitive and histoplasmin negative showed similar calcifications.

For non-residents of Tennessee the figures were 51.4 per cent pulmonary calcifications among the histoplasmin sensitive tuberculin non-sensitive group and 40 per cent for the tuberculin sensitive histoplasmin non-sensitive group.

Among 610 residents of Tennessee who showed pulmonary calcifications 87.4 per cent were histoplasmin sensitive and only 18.8 per cent tuberculin sensitive. The histoplasmin sensitivity was found to increase rapidly with increasing age from 1.9 per cent in the first year of life to 90 per cent in the 21-22 year group.

The development of tuberculin sensitivity showed a marked difference in the different economic strata. In the group from the lower economic stratum tuberculin sensitivity rose from 6.1 per cent in the 1-2 year age group to 42.8 per cent in the 17-18 year age group. In the higher economic stratum group the University group, the tuberculin sensitivity for the 17-18 year group was only 12.6 per cent.

No cases of pulmonary calcification were seen below five years of age but the incidence rose rapidly to 57.7 per cent in the 9-10 year group and then gradually to 66.7 per cent in the 19-20 year group.

In the graphic plotting of the above statistics a very close and definite correlation becomes apparent between histoplasmin sensitivity and pulmonary calcifications. The same correlation does not seem to exist with tuberculin sensitivity. When the statistical groups are broken down on a geographical basis the correlation between histoplasmin sensitivity and pulmonary calcification is very close. In general, it was noted that the percentage of histoplasmin reactors was higher in the states of the western Appalachian slope and those just west of the Mississippi River.

As to the significance of histoplasmin sensitivity 5 per cent of children in the 4-5 year age group are histoplasmin sensitive and were without any clinically significant infection. It has no value as an exclusion test since most cases with proved advanced histoplasmosis were histoplasmin-negative. The test is probably satisfactory, according to the author, as an exclusion test in mild acute, subacute and chronic cases. This would be comparable to the energy seen in tuberculin testing during

miliary infections. It also seems likely that histoplasmosis gives many nonspecific reactions and may serve only as an index of sensitivity to a group of fungi.—*Rolfe M. Harvey.*

WARING, J. I., and GREGG, D. B. Pulmonary calcifications and sensitivity to histoplasmin in Charleston, S. C. *Am. J. Dis. Child.*, Feb., 1947, 73, 139-142.

In a study of children of school age in Charleston County, S. C., contact tests with tuberculin and roentgenograms on 14 by 17 inch paper films were made on 494 children. Intradermal tests with histoplasmin could not be arranged for all the children. However, 8 with pulmonary calcification and negative reactions to tuberculin were re-examined and each was given an intradermal injection of 1:100 dilution of histoplasmin, and simultaneously an intradermal test with 0.1 mg. of old tuberculin was done. Five of the 8 reacted positively to histoplasmin. All of the 5 had either lived in or made prolonged visits in Kentucky, Tennessee, Alabama or Mississippi within the area of high incidence or sensitivity as determined in the study of the United States Public Health Service. The incidence of sensitivity to histoplasmin in school children was less than 2 per cent. The appearance of calcified pulmonary lesions in children associated with sensitivity to histoplasmin, was less than 1 per cent and it appeared to be an imported problem.

Three patients who were sensitive to histoplasmin showed roentgenographically multiple discrete calcifications more or less concentrated in the inner third of the pulmonary lung fields of both lungs, with bilateral hilar glandular calcifications. One of these patients reacted to both intradermal tests. Lesions of healed primary tuberculosis usually tend to be single nodules in the pulmonary fields with only one lymphatic course to the hilar nodes with few nodes calcified. These are generally more completely calcified and larger than those seen in histoplasmosis. However, in 2 patients who reacted positively to histoplasmin, rather large calcified solitary nodules were found, one of which appeared to be only partially calcified, emphasizing the impression that no reliable distinction can be made by roentgenographic appearance only. One patient who reacted negatively to both tests showed definite solitary

calcified nodules in each pulmonary field and in the left hilar nodes.—*R. S. Bromer.*

CAMIEL, MORTIMER R. Roentgenology of the massive conglomerate lesions of silicosis. *Am. Rev. Tuberc.*, June, 1945, 51, 527-531.

The author gives the following diagnostic criteria. Two cases are discussed.

1. Subapical or subclavicular location of the lesions is most common; the process is often located in the apices of the lower lobes.

2. The lesions are almost invariably bilateral.

3. There is a tendency toward symmetry.

4. There is frequently a clear zone of emphysema surrounding the lesions and separating them from both the hila and the chest wall. The separation from the hila is an important sign, since it excludes at once lesions which might arise in the hilar lymph nodes, such as Hodgkin's disease.

5. Emphysema over the remainder of the lung fields is almost invariably present.

6. The position of the lesions is usually longitudinal. The shape of these lesions does not form standard patterns, as may be seen with neoplasms or infarction, but their longitudinal position is helpful in recognition.

7. Confirmatory typical nodulation may be present.

8. The lesions in the separate lung fields incline toward a similar density and appearance. With primary carcinoma or tuberculosis on one side with spread to the other the appearance in the opposite lung field is different. The density may be much greater than with neoplasms.

9. Fibrous strands are frequently seen radiating outward from the lesions.

10. Diaphragmatic deformities are frequent. Limitation of diaphragmatic motion is common.

11. The trachea is usually in the midline.—*James J. McCort.*

DUNNER, LASAR, HERMON, R., and BAGNALL, D. J. T. Pneumoconiosis in dockers dealing with grain and seeds. *Brit. J. Radiol.*, Dec., 1946, 19, 506-511.

In London many ships containing grain are unloaded. Previously the work was done by men and shovels, but recently suction apparatus has been used. Either method produces much dust which is necessarily inhaled by the workers. A group of 55 dock workers who had had more or less prolonged contact with such dust was examined, and of the total, 26 had active pulmonary tuberculosis. Of the rest,

there were 11 cases of pneumoconiosis. These were carefully questioned to exclude the possibility of previous occupation in a dusty trade.

The kinds of grain handled were oats, barley, wheat, and maize, particularly; but there were also seeds, such as millet, cotton, dari, and rape. The worst grain for dust production was barley; the worst seed, cotton.

Samples of various dusts were examined for their silica (silicon dioxide) content. When the silica content is compared with that of dust known to be highly dangerous, it is seen that the dusts from these grains are potentially dangerous. No tubercle bacilli were found in the samples examined bacteriologically.

The diagnosis of pneumoconiosis was based on the roentgen findings rather than on clinical evidence for case finding. The ages of the eleven men with pneumoconiosis varied between thirty-six and fifty-nine years, and the duration of the occupation between two and forty years, with the average twenty-two. Most of these patients had had a cough for a long time, usually productive, had experienced dyspnea, with either a gradual or abrupt onset, and most were in good physical condition. The degree of dyspnea was not always consistent with the roentgen pulmonary findings. Likewise, there was considerable discrepancy between clinical signs and roentgenological manifestations. The roentgen findings were usually reticulation, mottling, fibrosis, or a combination of these, in any part of the lung.

The authors feel that the lesions are caused by the dust, but are unable to state which type of dust or what part of the dust causes the changes. They have demonstrated a dangerous amount of a known pathogenic agent.—*E. F. Lang.*

SCOTT, L. D. W., PARK, S. D. SCOTT, and LENDRUM, ALAN C. Symposium; the clinical, radiological and pathological aspects of pulmonary hemosiderosis. *Brit. J. Radiol.*, Mar., 1947, 20, 100-107.

Any pulmonary hemorrhage may result in deposition of hemosiderin in the lungs. It can be demonstrated roentgenologically in two conditions: pulmonary hemosiderosis of children, and mitral stenosis. A common occurrence in rheumatic heart disease with mitral stenosis is hemoptysis, and in some patients with a considerable degree of bleeding the focal deposits of hemosiderin may be demonstrable roentgenologically. The picture is that of miliary

deposits in the lung in rare instances. More often, in localized areas in the lung the faint deposits may be shown. In some individuals the deposits can be shown in roentgenograms of the lung after removal at autopsy when roentgenograms taken during life did not show them.

Occasionally the roentgen appearance is such that a diagnosis of miliary tuberculosis is suggested. Faint pulmonary hemosiderosis may be mistaken for vascular engorgement in congestive failure, but with improvement in the patient's clinical picture the vascular engorgement disappears while hemosiderin deposits persist. Other diseases which might give a similar appearance are pneumoconiosis, carcinomatosis, lymphangitis, sarcoid, bronchiolitis, miliary abscesses, leukemic infiltration, miliary chorion-epithelioma, sarcomatosis, status lymphaticus, syphilis, and fungus infections of various kinds.—*E. F. Lang.*

WOOD, DAVID A., and PIERSON, PHILIP H. Pulmonary alveolar adenomatosis in man; is this the same disease as Jaagsiekte in sheep? *Am. Rev. Tuberc.*, March, 1945, 51, 205-224.

The authors report a case of histopathologically benign pulmonary epithelial adenomatosis occurring chiefly in the right lower lobe of a telephone operator, fifty-seven years of age. Dyspnea with an initial dry cough gradually becoming productive was a prominent feature of the disease. Clinically the pulmonary adenomatosis was confined to the right lower lobe for a year. Foci, however, were found in the other lobes upon postmortem examination.

Histopathologically, the most prominent feature found was the multicentricity of hyperplastic columnar epithelial cells lining the alveolar walls, showing all degrees of proliferation from single lining to papillary and cyst adenomatous arrangements. In all sections there was a striking preservation of alveolar stroma devoid of epithelial invasion. Only hyperplastic alveolar changes were found, none being present in the bronchi.—*James J. McCort.*

TERPLAN, KORNEL. Anatomical studies on human tuberculosis. XIII. Incidental findings of isolated tuberculous foci in the lungs apart from the primary complex ("focal extension"). *Am. Rev. Tuberc.*, Feb., 1945 51, 91-132.

This study is based on detailed morphological analysis of tuberculous lesions in 6 children and 49 adults, including 3 cases of progressive primary tuberculosis in children and 1 case of active primary tuberculosis in an adult. In the remaining 45 cases with various causes of death the tuberculosis lesions were incidentally observed postmortem. In all of them, one or more additional focal lesions, apart from the primary complex, were found with the same histopathological structure and of either the same or only slightly smaller size as the primary focus. These additional lesions, whose post primary character was clear because the regional complex was missing, were located in various parts of both lungs, including the upper (apical and subapical) portions of the upper lobes.

Anatomical and topographical analysis of these lesions, especially of those found in a relatively recent state, suggests intrabronchial spread from one or more primary lesions in their early active phase as an important pathway. Grossly marked penetration from tuberculous hilar lymph nodes through the wall of the bronchus into the bronchial mucosa can also lead to focal lesions of primary focus character. In the majority of the cases studied there was no evidence of hematogenous tuberculosis.—*James J. McCort.*

TERPLAN, KORNEL. Anatomical studies on human tuberculosis. XIV. Tuberculous lesions in the apical and subapical field in connection with primary tuberculosis. *Am. Rev. Tuberc.*, Feb., 1945, 51, 133-171.

This morphological study was undertaken to determine how far clinical observations, suggesting that primary tuberculosis in adult life produces directly a more or less diffuse infiltration of the apical and subapical areas, could be supported by anatomical evidence obtained from detailed gross and histological analysis. Of 330 cases with various anatomical findings of tuberculosis, including 55 fatal cases of tuberculosis, localized tuberculous lesions from 1 to 5 cm. below the apex, without a recognizable primary focus, were present in only 6 instances. Thus this apparently primary tuberculous infiltration of the upper portions of one upper lobe proved a rather infrequent occurrence, below 2 per cent of the total incidence of tuberculous lesions found postmortem in 330 adult cases. If only the cases of acute or chronic fatal tuberculosis are included, this percentage is below 4.—*James J. McCort.*

TERPLAN, KORNEL. Anatomical studies on human tuberculosis. XV. Restricted pulmonary reinfection. *Am. Rev. Tuberc.*, Feb., 1945, 51, 172-200.

The anatomical and histological picture of true exogenous, reinfection, presented for the most part by lesions few in number or single, is described on the basis of complete morphological analysis in 28 cases. In all, the reinfection lesions were found incidentally postmortem and were of no clinical significance. In all there was a typical old primary complex present, with the primary focus and the corresponding regional lymph node lesions in a completely obsolete state, and with no sign of exacerbation in either the focus or the lymph nodes. There was no trace of old hematogenous tubercles anywhere, including the lungs, which could have been formed at the time of the first infection. In the absence of any complicating sequelae beyond the old, obsolete complex, the exogenous nature of the subapical and apical reinfection lesions appeared beyond doubt in these cases.—*James J. McCort.*

TERPLAN, KORNEL. Anatomical studies on human tuberculosis. XVI. Progressive reinfection. Part 1. *Am. Rev. Tuberc.*, April, 1945, 51, 321-350.

The anatomical picture in 18 cases of exogenous, progressive pulmonary reinfection tuberculosis is presented. In 15 of them 3 were the typical obsolete remnants of a primary pulmonary infection, in 1 a primary intestinal infection was present. In the remaining 2 cases primary focus or foci were obscured among multiple apical and subapical calcified tubercles of apparently post primary character; the hilar lymph nodes regional to these areas, however, were distinctly calcified, just as in any typical obsolete primary complex.

The anatomical-histological analysis of the entire material pointed in all cases to the exogenous nature of these post primary reinfection lesions. They were found in typical subapical and apical location in 17, and in the left lower lobe in 1 case. Lymphogenous spread from the progressive post primary reinfection lesions was pronounced in 10 cases out of 18; in some of them with massive caseation of the entire bronchomediastinal lymph node chain.—*James J. McCort.*

TERPLAN, KORNEL. Anatomical studies on human tuberculosis. XVII. Progressive rein-

fection. Part 2. *Am. Rev. Tuberc.*, April, 1945, 51, 351-388.

In this paper the anatomical findings in 12 cases of pulmonary reinfectious lesions combined with various forms of hematogenous tuberculosis are presented. The cause of death was not phthisic destruction of the lungs but hematogenous tuberculosis in all, including overwhelming miliary tuberculosis in 4, tuberculous meningitis in at least 3, tuberculoma of the brain, tuberculosis of the spine, tuberculous destruction of the adrenal glands and tuberculous serositis.

With one exception there was anatomical evidence of lymphogenous progression to the bronchomediastinal lymph nodes from the pulmonary reinfection lesions. In all cases except one there were obsolete remnants of a primary pulmonary or (in one case only) intestinal complex. No trace of a possible pathogenetic link between the obsolete first infection and the usually chronic fibrocaceous super- or reinfection lesions could be found.—*James J. McCort.*

TERPLAN, KORNEL. Anatomical studies on human tuberculosis. XVIII. Additional observations on progressive primary pulmonary tuberculosis in adults. *Am. Rev. Tuberc.*, Aug., 1945, 52, 155-163.

The anatomical findings in 7 cases of progressive primary tuberculosis in the young adult from twenty to thirty years are presented. They resemble closely the anatomical character of progressive primary tuberculosis in children including considerable lymphogenous spread from the primary lesion to the regional bronchomediastinal lymph nodes, cavitation of the primary focus followed by intrabronchial extension and overwhelming hematogenous miliary seeding with tuberculous meningitis. One unusual observation of caseated pleuritis contiguous to a recent primary parenchymal subpleural lesion—with but slight lymph node complex changes and with overwhelming miliary tuberculosis—is also included, and an apparently primary progressive phthisic form of pulmonary tuberculosis in a senile person, aged ninety-one, is added, suggesting that remnants of a primary complex may leave no grossly recognizable traces in later life, especially in senility.—*James J. McCort.*

TERPLAN, KORNEL. Anatomical studies on human tuberculosis. XIX. Protracted pri-

mary tuberculosis in the adult, with some observations on "lymphoglandular-endogenous reinfection (Ghon)." *Am. Rev. Tuberc.*, Sept., 1945, 52, 312-336.

The author states that the term endogenous reinfection was first used by Orth. According to Orth, it meant the manifestation of a new infection in a harbinger of tuberculous lesions by the same tubercle bacilli which had infected the body originally. It is, therefore, in terms usually applied in general pathology, a recurrence. This term "endogenous reinfection" was amplified by Ghon (Ghon, A. and Pototschnig, G.: *Beitr. z. Klin. d. Tuberk.*, 1919, 40, 103) with the adjective "lymphoglandular" referring specifically to the type which is caused by a local reactivation and extension with lymph nodes, the site of older tuberculous lesions, while the primary focus appears completely healed. It is thought to be immaterial in this discussion whether this reactivation of the tuberculous process followed a state of apparently long latency, as Ghon thought in his first publication on endogenous reinfection, or whether an exacerbation of the bronchomediastinal lymph node tuberculosis recurred in several phases.

The anatomical findings in 6 cases of primary protracted tuberculosis in adults are discussed. Four or possibly 5 of these represent changes of "endogeneous lymphoglandular reinfection" with hematogenous dissemination involving especially spleen, liver, kidneys, the lungs, pleura, peritoneum, and leptomeninges. A comparison of the entire anatomical picture in these cases with that seen in exogenous reinfection shows that the pulmonary lesions are clearly of hematogenous character and that they do not lead to further intrabronchial progression as seen in the common type of pulmonary tuberculosis.—*James F. McCort.*

TERPLAN, KORNEI. Anatomical studies on human tuberculosis. XX. Disseminated calcified small nodular hematogenous pulmonary tubercles, incidentally discovered. *Am. Rev. Tuberc.*, Dec., 1945, 52, 505-520.

An incidental postmortem finding in a sixty year old white farmer who was said to have been always in the best of health and who was killed accidentally, revealed nearly 200 parenchymatous calcified and chalky tubercles in fairly even distribution in both lungs, with no predilection of the apical and subapical areas, in the presence of multiple calcified and fibrous

tubercles in liver, spleen, and kidneys. This histopathological structure of the individual parenchymatous lesions does not permit any unequivocal interpretation in terms of pathogenesis without considering the anatomical picture in its entirety. The reported findings differ from those in "focal extension." The complete histopathological analysis of the parenchymatous pulmonary tubercles has disclosed various distinctive stages of structural regression between the soft chalky-fibrous, the chalky-calcified and the firm stony and calcified-ossified state. Together with the changes in the bronchomediastinal lymph nodes representing also various combinations of older and less old and possibly still active tuberculous lesions, they seem to point to protracted lymphogenous progression with repeated phases of hematogenous spread, leading to symmetrical dissemination of small nodular calcified and chalky-fibrous tubercles in both lungs.—*James F. McCort.*

DORMER, B. A., FRIEDLANDER, J., and WILES, F. J. Bronchography in pulmonary tuberculosis. III. Chronic fibroid phthisis—chronic productive tuberculosis. *Am. Rev. Tuberc.*, Jan., 1945, 51, 62-69.

The authors use a suspension of sulfonamide powder in lipiodol both in diagnosis and treatment. This combination is used in the belief that it may sterilize chronic bronchiectatic areas and cavities in cases of pulmonary tuberculosis in which the sputum has been positive for many years. It is suggested that this form of treatment should precede major thoracic surgery and that it may be a method of treatment for suppurative conditions of the lung.

Ten cases of chronic fibroid phthisis are described in which the authors used this method of diagnosis and treatment.—*James F. McCort.*

DORMER, B. A., FRIEDLANDER, J., and WILES, F. J. Bronchography in pulmonary tuberculosis. IV. A geographical adventure. *Am. Rev. Tuberc.*, May, 1945, 51, 455-462; June, 519-526.

This is a study of 16 patients examined by bronchography using iodized oil. The authors conclude that the most important factor in both pulmonary tuberculosis and septic infections of the lung is bronchial or bronchiolar block with the resulting atelectasis, cavitation or bronchiectasis and that the pathological processes of pulmonary tuberculosis are ade-

quately explained on this basis. It is also concluded that physical signs are not to be relied upon as accurate indications of a pulmonary process.—*James F. McCort.*

DORMER, B. A., FRIEDLANDER, J., and WILES, F. J. Bronchography in pulmonary tuberculosis. V. Artificial pneumothorax. *Am. Rev. Tuberc.*, July, 1945, 52, 21-35.

The mechanism of artificial pneumothorax is explained as follows: In an artificial pneumothorax the collapse is from the periphery. Reducing the subatmospheric intrapleural pressure allows retraction of the diseased area, and large numbers of alveoli cave in. The general retraction and shrinking of alveoli and connective tissue prevent further infection and tend to squeeze liquefied tuberculous material out of the blocked bronchioles leaving them patent. This allows healing by fibrosis of the approximated thin walls of recent cavities and recent bronchiectasis in the actual area of disease. At the same time, the surrounding alveoli, which would also have become diseased if their bronchioles had remained blocked, are now able to expand and occupy the space left by the contraction of the fibrosed area. In other words, pneumothorax is effective because it eliminates the blockages in the bronchial system.

On the other hand, pneumothorax is of no therapeutic value in a case where the bronchial block persists in spite of the pneumothorax. If a bronchogram prior to an attempted artificial pneumothorax shows old-standing thick-walled ectatic bronchi or thick-walled cavities, then it is of no avail to carry on with this form of treatment, as the ultimate result will be that the bronchiectasis or the cavities will still be present. The authors have found by experience that artificial pneumothorax is not a treatment for chronic bronchiectasis of non-tuberculous origin as for chronic lung abscess and logically should not be effective, if the origin of the condition is tuberculous.

Artificial pneumothorax with superatmospheric intrapleural pressure is a relic of the days when it was thought that the lung should be collapsed in the literal sense of the word. If persisted in, upsetting complications arise, the two most bothersome being tuberculous empyema and bronchopleural fistula.—*James F. McCort.*

DORMER, B. A., FRIEDLANDER, J., and WILES, F. J. Bronchography in pulmonary tuber-

culosis. VI. Thoracoplasty. *Am. Rev. Tuberc.*, Aug., 1945, 52, 145-154; Sept., 258-263.

The authors observe that the recent cavity which will not respond to artificial pneumothorax, especially a cavity in the upper part of the lung, is perhaps the ideal indication for thoracoplasty. The results in any other stage of tuberculosis cannot be predicted. Some cases emerge with a negative sputum, some with a positive, but one cannot say beforehand which case will attain a negative sputum and which will not. It is this very lack of the ability to predict the outcome of the operation that led the authors to study the bronchial tree in cases submitted for thoracoplasty and to study its reaction to each stage of the operation.

It is concluded that in a case with a single, relatively early apical cavity, which is the most suitable type for thoracoplasty, there may be no demonstrable bronchiectasis. In all other cases there is tuberculous bronchiectasis present before thoracoplasty and the bronchiectasis remains unchanged after the operation. It is this fact that makes it important to find some more logical form of therapy than thoracoplasty.—*James F. McCort.*

LODGE, THOMAS. The anatomy of the blood vessels of the human lung as applied to chest radiology. *Brit. J. Radiol.*, Jan., 1946, 19, 1-13.

This thesis fully reviews the literature regarding the anatomy of the blood vessels of the human lung, giving a brief review of many previous investigations, and pointing out the lack of correlation between the anatomical and the roentgenological appearances of these vessels.

By the use of celloidin models, roentgenography of the lungs following the injection of the vessels with barium sulphate suspension, and tomography of the living subject, the writer translates the anatomy of the lung specifically into terms of chest roentgenology.

Lodge presents detailed descriptions of all main branches of the pulmonary vascular tree, adhering largely to Ewart's terminology with a few modifications. Schematic drawings and illustrations clarify the description.

The bronchial tree is also discussed as there is a strong interdependence of the bronchial and vascular systems. There is a constant relationship of artery, bronchus, and vein proceeding counterclockwise in that order in

the right lung and clockwise in the left lung in the same order. The veins tend to be distant from the bronchi and to lie in their interspaces. They cross the bronchi at an angle and are never parallel with them. They also cross arteries sometimes almost at 90°. Variations of the pulmonary vessels are particularly likely to occur in the upper lobes, while variations are rarely found in the bronchial tree.

The author's anatomical studies confirm the existence of such variations which he lists as (1) variation of origin, (2) duplication, (3) size, (4) direction. His study of 100 normal chest roentgenograms shows that many vessels can be identified and also gives some idea of the variations which may occur within the limits of normality. His studies also permit him to describe the following characteristics of a blood vessel shadow. The shadows present a homogeneous opacity diminishing gradually in caliber and maintaining their constant relationship to an accompanying bronchus. They are either straight or gently curved but never tortuous. The shadow shows clearly defined edges and obviously proceeds toward the hilum of the lung or corresponds to the direction of a known normal vessel.—K. K. Latteier.

GROSS, ROBERT E., and WARE, PAUL F. The surgical significance of aortic arch anomalies. *Surg., Gynec. & Obst.*, Oct., 1946, 83, 435-448.

A brief résumé is made of the more common abnormalities of the aortic arch and the large arteries which arise from it. Many of the anomalies do not give important symptoms but others have considerable significance since they: (1) give rise to pressure on the esophagus and trachea; (2) impose a burden on the heart because of an arteriovenous type of shunt; or (3) lead to severe derangements in the circulation because of an obstruction in the aortic pathway.

1. In the first group of malformations under consideration, the esophagus or trachea (or both) are impinged upon by: (1) a right-sided aortic arch; (2) a double aortic arch; (3) a constricting ring of vessels (or remnants thereof); or (4) by an anomalous right subclavian artery.

2. A right-sided aortic arch cannot be changed by surgical means, but if this abnormally placed structure is attached by a ligamentum arteriosum (or a patent ductus arteriosus) to the pulmonary artery so that this latter vessel is pulled back against the trachea or the left

side of the esophagus—then division of the ligament (or the ductus) should give some relief.

3. When a double (or split) aortic arch gives respiratory distress, the patient can be greatly helped by cutting the anterior (left) limb.

4. When dysphagia lusoria (dysphagia due to a lusus naturae—a trick or deception of nature) occurs from a right subclavian artery (which originates from the left side of the aortic arch), the symptoms can be abolished by dividing the artery so that it no longer presses on the esophagus.

5. Humans with a patent ductus arteriosus are subject to certain hazards, particularly in mid-life. The shunt can greatly increase the work of the heart and lead to varying degrees of embarrassment or failure. Furthermore, the open ductus is frequently the seat of superimposed bacterial infection. While some individuals live a long and active life with a patent ductus arteriosus—particularly if it is a small one—statistics indicate that the average length of life is little more than half of the normal expectancy. Surgical closure of the ductus has been shown to have very beneficial effects on the cardiovascular apparatus. While surgery can be deferred until symptoms have developed, the technical difficulties of operation at such times is considerable. In contrast, the closure of a ductus at an early age can be accomplished with a negligible risk, and hence the authors recommend operation in childhood or young adult life before complications have developed. A widening experience in this field makes one feel that ligation of a ductus is usually satisfactory, but that complete division of the vessel is a much superior procedure because it insures complete interruption of the shunt and precludes any possibility of its re-establishment.

6. Individuals with a high degree of obstruction in the distal part of the aortic arch or in the first part of the descending aorta may live to advanced ages with little or no difficulty but most of them develop serious or even fatal complications in mid-life. Outstanding among the sequelae of coarctation of the aorta is hypertension which usually appears in the upper part of the body. With this increased pressure may come all of the disorders and dangers of the hypertensive state. Experimental observations show that a section of the upper thoracic aorta can be excised and that the open ends of the aorta can be satisfactorily joined. Such a procedure has been adapted to humans; a narrowed

(or completely obstructed) segment of the aorta can be removed and the remaining ends of the aorta can be anastomosed. After performance of this operation, the hypertension is quickly relieved.—*Mary Frances Vastine.*

WEISS, MORRIS, and LONG, LEONARD. Simple non-sphincteric localized esophageal spasm. *Am. J. Digest. Dis.*, Dec., 1946, 13, 375.

Spasm of the upper end of the esophagus (cricopharyngeal spasm) and of the lower end (cardiospasm) are common entities. Spasm of the remainder of the esophagus is usually secondary to organic disease but simple non-sphincteric spasm does occur. It may be either localized or diffuse, the former type probably being the most common. Either type may occur in any portion of the esophagus and may be transient or prolonged. Although simple non-sphincteric spasm apparently is not frequently diagnosed, it probably is more common than the literature would indicate since the condition may be of very short duration and the symptoms too mild to require roentgenographic study. It may occur in any age group and both sexes are equally affected. The exact etiology is still in doubt. Nervous instability plays an important part; however, reflex stimulation from lesions of thoracic or abdominal viscera may also be exciting factors.

Either dysphagia or pain may be the outstanding symptoms, the pain varying from a dull substernal ache to severe shooting paroxysms and may lead to a diagnosis of angina pectoris.

In the reported case the patient's statement that he swallowed lye during childhood made appear on admission that this was an organic stricture of the esophagus. The roentgenographic examination at this time seemed to support this. But the history of previous attacks with asymptomatic intervening periods together with roentgenographic and esophagosopic findings of obstruction that were transient in an individual with nervous instability indicates its functional nature. The lack of evidence of organic disease, intrinsic or extrinsic, supports this impression.

The case is unusual in that the spasm is localized in the upper third of the esophagus but below the cricopharyngeus. The symptoms are very similar to those seen in cricopharyngeal spasm and differentiation from it or organic obstruction would be difficult without roentgenographic and/or esophagosopic examination.—*Franz J. Lust.*

RAFSKY, HENRY A., and HERZIG, WILLIAM. Scleroderma with oesophageal symptoms. *Gastroenterology*, Jan., 1946, 6, 35-39.

It is well known today that scleroderma is recognized as the skin manifestation of a disease which affects several systems of the human organism. In the 2 reported cases, the skeletal, vascular and gastrointestinal systems showed typical alterations aside from the skin changes. The differential diagnosis may be confusing and misleading, depending upon the signs and symptoms presented at the onset of the disease. The first case showed circulatory impairment in the hands and feet initially which could have been interpreted as Raynaud's or Buerger's disease. The dysphagia, which appeared later on could lead one to suspect the patient had an idiopathic cardiospasm, a Plummer-Vinson symptom, neoplasm of the esophagus, a diverticulum or possibly a peptogenic disturbance. The patient finally presented almost simultaneously arthritic and skin changes which are frequently seen in osteorheumatoid arthritis.

The biopsy showed normal squamous cells. Perhaps the biopsy of the atrophic area did not penetrate deeply enough. The roentgen study of the esophagus showed that the lower half was markedly dilated with spasm (achalasia) at the cardia. Under the fluoroscope one could see the cardia relax after a while and the barium enter the stomach.

The findings were very similar in the second reported case.—*Franz J. Lust.*

ABDOMEN

MENDELSON, E. A. Hiatus hernia of the stomach as a source of gastro-intestinal bleeding. *Radiology*, May, 1946, 46, 502-506.

The hiatus hernia may or may not be combined with a congenitally short esophagus. Insufficiency of the muscular hiatus and of the surrounding connective tissue, acquired with advancing age, is considered the decisive etiologic factor.

The cause of bleeding in hiatus hernia is considered to be venous congestion in the herniated portion of the stomach due to muscular compression of the diaphragm. The swollen and congested mucosal layer can easily be traumatized with production of superficial bleeding erosions or deeper ulceration.

Sixteen cases of hiatus hernia of the stomach have been observed in 1,000 consecutive gastrointestinal examinations at the Sparks Memorial

Hospital and the Holt-Krock Clinic. Four case histories are given in detail demonstrating hiatus hernia of the stomach as the source of intestinal bleeding, manifesting itself in hematemesis, melena or microcytic anemia.

The symptoms of hiatus hernia may simulate coronary artery disease and intra-abdominal conditions.—*F. B. Markunas.*

SCOTT, W. G. Radiographic diagnosis of prolapsed redundant gastric mucosa into the duodenum, with remarks on the clinical significance and treatment. *Radiology*, June, 1946, 46, 547-568.

Because gastric mucosa prolapsing into the duodenum is often diagnosed as duodenal ulcer or duodenitis and when recognized is considered of no clinical significance, Scott has reviewed the subject. His conclusions are illustrated by cases seen in the military service.

In a series of 1,346 successive roentgen examinations of the upper gastrointestinal tract of young adult males, this condition was found as often as gastric ulcer. The etiology appears to be an excessive and abnormal mobility of the pyloric mucosa on the muscularis.

The symptoms are not sufficiently characteristic to permit a clinical diagnosis. The diagnosis depends on the roentgenologic findings and the ruling out of other gastrointestinal diseases. The roentgen findings are quite characteristic and consist of a central mushroom or cauliflower-like defect in the base of the duodenal cap. It is practically impossible to distinguish prolapsing mucosa from prolapsing pedunculated tumors or polyps.

The condition is treated surgically with excellent results. Symptoms such as bleeding and persistent pain in spite of dietary regulation are indications for surgery.—*J. H. Harris.*

BANK, JOSEPH, PEARCE, ALEXANDER E., and GILMORE, JOHN H. Hypertrophic gastritis simulating neoplasm. *Am. J. Digest. Dis.*, Nov., 1946, 13, 344-346.

The authors report the case of a twenty-six year old soldier who had been suffering from epigastric distress for several years. Before admission to the hospital he had lost 8 pounds. The examination of the gastric contents revealed a hyperacidity. Fasting free HCl 90, total acidity 110, highest postcibal acidity free 115, total acidity, 130. The roentgenological examination gave the impression of a large neoplasm in the region of the antrum of the

stomach. No peristalsis in the involved area could be seen.

At operation, the surgeon had the impression of a polypoid tumor in the lumen of the stomach. A scar of an old prepyloric ulcer was found. The pathological examination showed large prominent rugae with extensive convolution. On section, the large folds showed a very thick mucosa, measuring up to 3.5 mm., with an exaggerated muscularis mucosae. The submucosa appeared greatly edematous. No neoplastic masses could be found.—*Franz J. Lust.*

CASH, I. I., and RAPPOPORT, A. E. Reticulum cell sarcoma of the stomach. *Gastroenterology*, Jan., 1946, 6, 40-49.

A rare case of reticulum cell sarcoma of the stomach is reported. These cells are derived from the germinal centers of the lymphoid tissue located in the gastric submucosa. Clinically the symptoms are protean as in gastric carcinoma. Gastroscopecally, the lesion appears not unlike that of an infiltrating lymphosarcoma. The lesion tends to ulcerate and infiltrate surrounding organs, and in this case, a "forme fruste" perforation was present.

The roentgenological examination revealed an extensive prepyloric lesion which appeared polypoid in nature with small and large filling defects in the distal third of the stomach and marked enlargement and distortion of the gastric rugal pattern over the small area proximal to this. Some peristaltic waves could be observed through this same area.

A subtotal gastric resection followed by irradiation is the therapy of choice. The prognosis is debatable, although the authors believe that five year cure is probable.—*Franz J. Lust.*

TENNENT, WILLIAM. Recent advances in investigation of the small intestine. *Brit. J. Radiol.*, Jan., 1946, 19, 22-26.

Quite different techniques are required in examination of the small intestine with reference to study of the physiological activity and the search for organic lesions. In studying the physiological activity (as in celiac disease, idiopathic steatorrhea, and so-called deficiency diseases) a fractional barium meal is the technique of choice. Barium suspended in isotonic saline and heated to body temperature may, when taken orally at fifteen minute intervals, evenly fill the small intestine and allow study of the mucosal pattern, peristalsis, and absorptive capacity of the gut. The organic

lesions (as regional ileitis, neoplasm, and intestinal obstruction) are best investigated by means of intestinal intubation. The small intestinal enema administered by gravity through an ordinary rubber tube directly into the duodenum often allows steady filling of the small bowel in the same manner as with colonic enema. Though this method has frequently demonstrated adhesions, regional ileitis and pressure from extraluminal tumors, it is obviously dangerous to use in the presence of even partial obstruction. Frequently gastric reflux interferes with the examination. The injection of barium through a Miller-Abbott tube is much more satisfactory allowing localization of the site to be examined so that only small quantities of barium need be injected. The inflated balloon may be allowed to sweep the small amount of barium forward in front of it or it may be used to block the third part of the duodenum while barium is injected into the proximal duodenum and its contours studied. Two balloons can also be fitted to the same tube and used to isolate any particular segment of bowel.—*K. K. Latteier.*

DALLOS, ARTHUR. Roentgenological evidence of appendiceal abscesses. *Am. J. Digest. Dis.*, Sept., 1946, 13, 279-284.

Dallos discusses the roentgenological findings in patients where appendiceal abscess started weeks or months after their acute abdominal symptoms had subsided or in which the patients could not recall any acute abdominal illness. These are cases of a chronic type in which as a result of a suppurative infection the appendix has been perforated and become walled off producing a localized abscess with tumor formation.

The author reports 5 such cases and draws the following conclusions for the roentgenological diagnosis: (1) filling defects, either extrinsic or intrinsic or both; (2) fixation of the cecum and last loop of the ileum; (3) elevation and displacement of the ileum; (4) hyperirritability and hypermotility with cecal spasm; (5) sensitiveness and tenderness of the area; (6) no visualization of the appendix.

The surgical procedure must be decided at the operation itself. In the reported cases, 1 had an appendectomy, 1 appendectomy with drainage of the abscess, 2 ileotransversostomy and 1 an ileocecal resection.—*Franz J. Lust.*

GAUSS, HARRY, and WEINSTEIN, L. J. Toxic sulfonamide colitis. *Am. J. Digest. Dis.*, Dec., 1946, 13, 373.

Three cases of toxic sulfonamide colitis are reported following the oral administration of sulfathiazole in 1 instance and sulfapyridine in 2 instances. Although seen under different circumstances, the 3 patients presented singularly similar clinical pictures of the digestive tract complication. In all of them the colon was swollen and hemorrhagic to the full length of the 25 cm. scope. The patients all had a severe diarrhea with frequent hemorrhagic stools associated with severe abdominal cramps. With the withdrawal of the sulfonamides the symptoms subsided, and the colon returned to its normal appearance, leading to the conclusion that the hemorrhagic colitis was the direct result of the toxic effect of the ingested sulfonamide.—*Franz J. Lust.*

COGSWELL, H. D., and THOMPSON, HUGH C. Duplication of the rectum. *Am. J. Dis. Child.*, Feb., 1947, 73, 167-177.

Duplications of the alimentary tract or, as they have been more commonly called, enterogeneous cysts or diverticula, are of great rarity, especially in the rectum. The case reported in this paper, according to the opinion of the authors, is unique in that the duplication of the rectum assumed the characteristics of both a cyst and a diverticulum during the time the patient was being observed.

The patient was a white girl, who on admission to the hospital at the age of seven weeks had considerable distention of the abdomen with an umbilical hernia. The feces were loose and yellow and occasionally contained blood. Roentgenologic studies showed a large air-containing sac of bowel, displacing the abdominal contents to the right and apparently arising from the pelvis. A lateral view showed that the splenic flexure and transverse colon were posterior to the cyst-like shadow. No communication between the colon and cyst could be demonstrated. The patient was operated upon. In commenting upon the operative findings, the authors state that the case offers argument in favor of designating the condition found as a "duplication" rather than as a cyst or diverticulum as both of the latter existed in this instance. At the time of operation a cyst (defined as any sac, normal or otherwise, especially one which contains a liquid or semisolid) was

found. After drainage, this was found to be unquestionably a diverticulum (a pouch, leading off from a main cavity or tube). The patient had most of the usual symptoms of duplication, namely, abdominal colic, distention of the abdomen, increased peristalsis and constipation with one exception, however, vomiting. The latter was most probably absent because of the low position of compression of the bowel.

An unusual feature was the presence of a large amount of air and later pus in the duplication. The authors suggest that there must have been some "trap door" or "ball valve" mechanism which allowed the passage of gas from the rectum into the duplication but prevented its escape. It would also appear that the greater the intraluminal pressure existing in the duplication, the less possibility there was of an escape of its contents into the lumen of the colon.

As defined by Ladd and Gross, duplications of the alimentary tract are hollow structures which possess a muscular coat and are lined with epithelium similar to that found in some portion of the gastrointestinal tract. They may arise in any portion of the tract from the tongue to the anus, the most common site being the ileocecal valve, and may present themselves in any position at the periphery of the intestine, that is, antimesenteric or mesenteric, often lying between the folds of the mesentery. Their position in the wall of the alimentary tract also varies in that they may be found in the subserous or submucous layers. The shape likewise is inconsistent and can be tubular or globular, so that a variable length of bowel (a duplication), blind on both ends, may exist in close proximity to the main intestine or even inside it. In those instances in which a communication exists with the neighboring intestinal tract, the contents will be usually similar to those in the intestine. Those without a communication to the lumen of the bowel, are cystic and contain a clear, colorless, mucoid substance.

The relief of the acute symptoms was effected by marsupialization of the duplication, and this procedure is recommended for cases of this type.—R. S. Bromer.

COMFORT, MANFRED W., GAMBILL, EARL E., and BAGGENSTOSS, A. H. Chronic relapsing pancreatitis. *Gastroenterology*, April, 1946, 6, 239-285; May, 376-408.

On the basis of 29 cases of chronic relapsing pancreatitis without associated disease of the

biliary or gastroduodenal tracts of a degree sufficient to influence the clinical picture the following conclusions are drawn:

(1) Chronic relapsing pancreatitis appears to represent the summation of repeated attacks of acute interstitial pancreatitis or repeated sublethal attacks of so-called acute hemorrhagic pancreatitis or a combination of the two types of pancreatitis. Interstitial fibrosis and residual necrosis and atrophy are the constant chronic changes. Regions of calcification or stone, pseudo-cysts and abscess are less frequent but striking residua.

(2) Chronic relapsing pancreatitis characteristically is a disease of recurring exacerbations separated by short or long intervals of relative clinical quiescence. During the early stages of the disease, the clinician may not be able to demonstrate existence of pathologic physiologic changes, yet the surgeon or the pathologist will be able to demonstrate pathologic changes in the organ. However, later in the course of the disease, the destruction of the pancreas will reach the point where disturbances of internal and external secretion, pancreatic calcification and other sequelae will be demonstrable at all times.

(3) The clinical signs are recurring, prolonged attacks of severe pains in the upper part of the abdomen, and disturbances of function of the acinar and islet cells and certain sequelae. Disturbances of function may be transitory and mild during the acute episodes before widespread anatomic destruction has occurred. Glycosuria and hyperglycemia, steatorrhea and creatorrhea appear and persist. Pancreatic stones and calcification appear in roentgenograms of the organ and the enlarged organ and cysts may be felt.

(4) The clinical signs are due not only to the disease in the pancreas but also to the effect of the disease on neighboring organs. The most striking of these sequelae are obstruction of the common bile duct, jaundice, hepatitis, distention of the gallbladder and obstruction of the duodenum.

(5) The treatment of choice is surgical. The results of conservative surgical procedures (internal or external drainage of the biliary tract and pancreatic cysts, pancreolithotomy, or gastroentrostomy for duodenal obstruction) are sufficiently good to warrant frequent and early use. Radical surgical procedures (partial or total pancreatectomy) may be utilized if the

conservative ones have failed and then only for the relief of persistent pains. Medical measures include diet, replacement therapy, drugs for control of pain and measures in case of shock.—*Franz J. Lust.*

GYNECOLOGY AND OBSTETRICS

JEFFERISS, D., and SAMUEL, ERIC. Pelvigraphy. *Brit. J. Radiol.*, Nov., 1946, 19, 462-468.

Kjellberg introduced a method of examination of the female pelvis with a water-soluble contrast medium as is used in excretory urography. The material is injected into the uterus and tubes through a uterine catheter, under roentgenoscopic control. When the uterus and fallopian tubes are outlined a film is made which gives the same information as the conventional examination with lipiodol. After this, more material is injected, and the serosal wall of the uterus, the ovaries, the pouch of Douglas, and the broad ligaments may be identified. Antero-posterior films are made with the patient supine and in each lateral decubitus.

In the face of a hydrosalpinx, a satisfactory lipiodol salpingogram is usually not obtained, because of the viscosity of the medium. Water-soluble dye mixes with the fluid in the tube and in some views even layering of the two fluids may be observed. By this method ovarian tumors are easily outlined, as are tumors of the peritoneal aspect of the uterus. In lateral views the thickness of the uterine wall can be outlined between the two layers of opaque medium. Tumors in the broad ligaments may be outlined as space occupying defects, or by their displacement of the uterus or distortion of the tube on that side.

The opaque medium is rapidly absorbed from the peritoneal cavity, and the procedure is no more dangerous than an excretory urogram from the standpoint of toxicity of the medium. The method is of course contraindicated in patients with recent pelvic inflammatory disease.—*E. F. Lang.*

ALLEN, E. PETER. Standardised radiological pelvimetry. I. Quantitative aspects. *Brit. J. Radiol.*, Feb., 1947, 20, 45-54.

Two of the factors preventing proper assessment of the importance of roentgen pelvimetry at present are the variation in the methods and the variation in the bases of interpretation. Each author stresses his own method, and each decides which features of the pelvis are of ob-

stetrical significance. Comparison of any two methods is therefore difficult. An acceptable standard system of pelvimetry should be capable of measuring all the significant pelvic diameters with sufficient accuracy to be useful. It must use standard apparatus. It should be simple enough for one not trained in mathematics, and it must be concise and objective enough to be accurate in the hands of an inexperienced radiologist.

Considerable variation in opinion exists as to which diameters to measure. The major problem is clarification of the status of the true or obstetrical conjugate. Many authors have questioned the importance of the anterior upper margin of the sacrum as the posterior end-point, and these would place the end-point where the iliopectineal lines would meet if extended. This would place it in the plane of the widest transverse diameter of the brim and would thus represent the "available" antero-posterior diameter, according to Caldwell and Moloy. The author examined 12 dried female pelvises and found that in only a minority of cases do these two lines lie in the same plane. The point on the anterior portion of the sacrum to be taken as the posterior point of the conjugate should be that point which is closest to the symphysis pubis. In patients with an acute pubosacral angle this point may be as low as the lower part of the first sacral body. In the usual case, however, with a pubosacral angle of 90 degrees or more, the sacral promontory is more nearly correct.

Other measurements of the inlet are not so important. The end-points of the transverse diameter are definite. The number of other measurements of the brim should be reduced to a minimum, since the head is available as a pelvimeter in most cases.

In measurements of the midplane of the pelvis, the significant transverse diameter is usually taken as the interspinous. Actually, however, there is considerable space anterior to this which is available to the descending head if the interspinous diameter is narrow. In this case, the head takes the path of least resistance and then the narrowest available diameter at that level is that between the flat bodies of the ischia anterior to the spines. The anteroposterior diameter should be measured from the lower part of the symphysis to the lowermost fixed sacral segment.

Measurement of the outlet is difficult because of the lack of definite end-points. The most im-

portant consideration from the standpoint of roentgen pelvimetry is measurement of the subpubic angle. This measurement is best made with the patient sitting on the film.

A subsidiary method of pelvimetry is calculation of the area of the inlet. This is an important method of consolidating the anteroposterior and transverse measurements which are given in linear dimensions. It is most useful in generally contracted pelves when the inlet remains a circle or a regular ellipse. When the inlet is flat or wedge-shaped with a considerable difference between the two diameters, the area may be misleading.—*E. F. Lang.*

ALLEN, E. PETER. Standardised radiological pelvimetry. II. Qualitative. *Brit. J. Radiol.*, Mar., 1947, 20, 108-118.

The shape of the pelvis, as distinguished from the size, is an important factor in the course of labor. Systems of classification have relied almost entirely on the brim measurements because these diameters are most easily measured, and are the most important, obstetrically. In order to define a pelvic type exactly, it must be described mathematically rather than as a sense impression of shape.

There have been four important different systems described. In 1885 Turner classified pelves according to the ratio between the anteroposterior and transverse diameters of the brim. Thoms extended this by using instead of the ratio the actual difference between the two measurements. Caldwell and Moloy use four main types and ten subtypes in describing the pelvis, and the approach is through sense impressions of shape without an exact mathematical basis. In 1942 Steele and Javert modified the work of Caldwell and Moloy by specifying normal diameters and they devised a set of semigeometrical figures for superimposition on a roentgenogram.

The author has examined these systems in some detail, and finds each wanting. The best compromise, he feels, is some expression of ratios between the five diameters of the pelvic brim with limiting values describing the four main types.

The android type of pelvis is most satisfactorily described as having a ratio of less than 40 per cent between the posterior sagittal and the conjugate diameters. Suggested other standards are: round pelvis has a brim index of 85 to 100 per cent; long oval pelvis has a brim index over 100 per cent; flat pelvis has a brim index

under 85 per cent. Any of these may have android posterior segments.

It should be realized that greatest advantage to the patient can be achieved by actual consultation between the obstetrician and radiologist while viewing the films.—*E. F. Lang.*

GENITOURINARY SYSTEM

DEMING, C. L. The prognosis and problems in renal tumors. *J. Urol.*, June, 1946, 55, 571-582.

This article summarizes a detailed study of 82 renal tumors seen in the New Haven Hospital in twenty-three years. The author found that only 13.4 per cent of his series of cases occurred in children in contrast to the commonly quoted figures of 30 per cent. Of the 11 cases occurring in children only 3 were Wilms' tumors. His figures also show a 19.5 per cent survival rate at five years, one-half of whom were free from disease.

The usual sites of metastases are the lungs, liver, lymph nodes and the opposite kidney in that order.

In regard to treatment, the author states that irradiation may reduce the size of the tumor in some cases increasing the feasibility of surgical removal of the tumor. It also may cause temporary disappearance of metastatic lung nodules but he feels that the value of this is outweighed by the production of fibrotic pneumonitis. Irradiation should not be employed without a histopathologic diagnosis of a tumor which is radiosensitive.

The survival rate did not seem to vary significantly in those with immediate treatment and those in whom there was a delay in diagnosis and treatment.—*Rolfe M. Harvey.*

NESBIT, R. M., and ADAMS, F. M. Wilms' tumor; review of 16 cases. *J. Pediat.*, Sept., 1946, 29, 295-303.

The survival rate for cases of Wilms' tumor has been reported as uniformly low. The best previously reported survival figure was that of Ladd and White, who reported a two year survival of 23.3 per cent. The authors report a series of 16 cases with a three and one-half year survival rate of 50 per cent. Seventy-five per cent of their cases were under three years of age.

Wilms' tumors are usually silent and are discovered accidentally by the nurse or mother of the child who notices the presence of an abdominal mass. Symptoms of weight loss, pallor,

vomiting and pain mean delay in seeking medical advice. The diagnosis should be suspected from the history of progressive enlargement of the abdomen in a child under five and the finding of a firm non-tender mass in the abdomen. The greatest difficulty in diagnosis is from an adrenal neuroblastoma. The diagnosis can be confirmed by pyelography. The characteristic changes in the pyelogram are: (1) distortion of the renal pelvis and calices, (2) displacement of the renal pelvis, and (3) non-visualization of the renal pelvis.

Methods of treatment vary. The authors believe preoperative irradiation should be used only when the size of the tumor makes operative removal a difficult technical procedure. All patients should be given postoperative irradiation.—*Rolfe M. Harvey.*

AUERBACH, O., BRINES, O. A., and YAGUDA, A.
Neoplasms of the testis. *J. Urol.*, Sept., 1946, 56, 368-374.

In a three year period at a Naval Hospital which had 150 beds devoted to treatment of malignant disease 26 autopsies were performed on patients who died of testicular malignancy, an incidence of 20 per cent of all deaths from malignancy. The ages ranged from nineteen to fifty years. History of preceding trauma was rarely noted. The duration of life following establishment of the diagnosis varied from two to twenty-two months and varied inversely with the duration of the disease before the diagnosis was made.

Twenty-three of 26 cases were subjected to an orchidectomy. All cases received postoperative irradiation. This was given to the chest, abdomen and any enlarged nodes noted in the axillary and supraclavicular regions.

The commonest presenting symptom was painless enlargement of the testis. In 92 per cent of cases a large palpable mass was present at the level of the celiac axis due to retroperitoneal nodes. In 79 per cent of cases the liver was the seat of metastases. In 80 per cent of cases the mediastinal lymph nodes were involved. Metastases were present in the lungs in 85 per cent of cases.

Various classifications of testicular tumors are discussed.—*Rolfe M. Harvey.*

NERVOUS SYSTEM

ULMER, JACK L., and MAYFIELD, FRANK H.
Causalgia; study of 75 cases. *Surg., Gynec. & Obst.*, Dec., 1946, 83, 789-796.

The data from 75 cases of causalgia due to war wounds of large mixed peripheral nerves have been presented and the following conclusions are drawn.

(1) The pathologic mechanism is obscure.

(2) The disorder is characterized by burning pain in association with vasomotor disturbances in the distal part of the extremity.

(3) The vasomotor disturbances are of two types, vasoconstriction or vasodilatation. The possibility that the vasomotor state may vary in any case is recognized but has not been observed.

(4) The pain can be relieved by appropriate sympathectomy. The sympathectomy must be complete, however, and with lesions involving the upper portion of the sciatic nerve, removal of the sympathetic chain as high as the eleventh dorsal ganglion may be required. For lesions of the upper extremity preganglionic operation is adequate.

(5) Procaine block of the appropriate chain is a necessary diagnostic procedure.

(6) Repeated procaine block as a therapeutic agent has not been effective in the authors' hands. Certain patients have improved with this procedure, but none has been completely relieved.

(7) Resection of the injured segment of nerve will provide relief. Neurolysis and periarterial sympathectomy at the level of the injury are ineffective.

(8) Sympathectomy should be done as soon as the diagnosis is established, to prevent the psychic trauma of prolonged pain and crippling joint stiffness.

(9) Causalgia has been noted only with incomplete nerve lesions.

(10) Recovery of function is often rapid after relief of pain. Consequently, primary neuro-rhaphy is rarely indicated.—*Mary Frances Vastine.*

SKELETAL SYSTEM

COSS, J. A., JR., and BOOTS, R. H. Juvenile rheumatoid arthritis; study of 56 cases with a note on skeletal changes. *J. Pediat.*, Aug., 1946, 29, 143-156.

The authors have observed 56 cases of rheumatoid arthritis in children since the organization of their clinic in 1928. They have discarded the term Still's disease since they do not consider it a separate entity from rheumatoid arthritis. The diagnosis depends on the presence of periarticular changes such as swelling, con-

tractures, loss of motion, joint effusions, characteristic roentgen changes, muscle atrophy, subcutaneous nodules, enlarged lymph nodes, splenomegaly and hepatomegaly, persisting over a period of years with or without associated systemic changes.

In the authors' series of cases the ratio of females to males was 5:1, the same as the adult ratio. Fifty-seven per cent of cases had a history of respiratory tract infection in association with the arthritis or preceding it; 60 per cent of cases had generalized glandular enlargement. Practically all patients complained of pain at some time during their illness. Forty-seven per cent had some cardiac disturbance; 80 per cent had a moderate anemia. In general, the higher the leukocytosis, the poorer the prognosis.

The authors have used four criteria in the roentgen diagnosis of skeletal changes in juvenile rheumatoid arthritis: (1) decalcification, (2) bone destruction, (3) joint space narrowing, and (4) soft tissue changes. Roentgen evidence of joint changes, as in adults, appears late. In general, the roentgen picture is similar to that in adults.

Among interesting changes noted in their series were fusion of cervical vertebral bodies which suggested failure of segmentation but which was proved to be fusion by referring to earlier films which were normal, brachydactylia and brachygnathia.

The authors conclude their report with illustrative case abstracts.—*Rolfe M. Harvey.*

LEONARD, D. W., and COHEN, L. Nonrachitic bowlegs in childhood; osteochondrosis deformans tibiae. *J. Pediat.*, Oct., 1946, 29, 477-484.

Many medical men are inclined to attribute bowing of the legs in childhood to rickets alone. However, the syndrome of tibia vara or osteochondrosis tibiae deformans must not be forgotten in the differential diagnosis. Blount first described this entity and differentiated it from rickets, Ollier's dyschondroplasia, syphilis, tuberculosis and osteochondritis. The syndrome has been divided into an infantile and an adolescent type.

The bowing occurs as an abrupt angulation just below the tibial condyles, the shaft of the tibia being straight beyond the point of angulation. On physical examination an enlargement of the medial condyle can be palpated. The medial condyle is prominent on the roentgen film as a beak-like projection. The deformity

has been attributed to delayed ossification of the medial half of the upper tibial epiphysis.

The authors include a chart to aid in differentiating the condition from rickets and Ollier's dyschondroplasia. He emphasizes the normal epiphyseal line in tibia vara which, however, would not help in differentiating a healed rickets. Most of his differential points appear concerned with an active rickets, which, in the reviewer's mind, would not present the problem that a healed rickets with bowing would present.

The article is concluded with a discussion of the orthopedic management of the condition.—*Rolfe M. Harvey.*

MURRAY, GORDON. End results of bone-grafting for non-union of the carpal navicular. *J. Bone & Joint Surg.*, Oct., 1946, 28, 749-756.

Gordon reports the results in 100 cases of bone-grafting for fractures of the carpal navicular. Bony union occurred in 96 patients. In some patients the range of motion was 100 per cent in all directions without any disability or discomfort. In some of the others, where there had been prolonged non-union and where a doubtful amount of arthritis was present in the wrist, the range of motion did not return to normal. However, the range of motion was useful and painless, and was sufficient so that the patients were able to return to their original work without discomfort or disability. The grafted navicular had a healthy appearance on roentgen examination as long as sixteen years after operation.

He enumerates six principles which must be followed to obtain the best results. The contraindications for operation for non-union of the navicular he states are (1) practically all early fractures, if splinted adequately will unite, so that bone-grafting for recent fractures is not a necessity; (2) in fractures in which non-union has existed for such length of time that there is arthritis in the wrist, disappearance of the articular cartilage between the navicular and the radius, or elongation of the styloid process of the radius, grafting should not be done. Even though the bone should unit solidly, the disability due to the arthritis in the wrist will not be corrected.

The presence of aseptic necrosis of the proximal fragment is not a contraindication, but is an absolute indication for bone-grafting, provided generalized arthritic changes are not present in the wrist. With grafting, the devitalized frag-

ment becomes revascularized and the fracture unites in most cases. One essential reason for doing a bone-graft in non-union of fracture of the navicular is that, if the non-union continues for a long period of time, arthritis of the wrist joint develops.—*R. S. Bromer.*

ZAGLIO, EDMOND R., and HARRIS, M. H. Deformity of the radius produced by an aneurysm. *J. Bone & Joint Surg.*, July, 1946, 28, 635-638.

The authors report a type of deformity caused by injury sustained in World War II which to their knowledge has not previously been reported. The patient was a soldier, aged twenty-two, wounded through the right forearm by machine-gun fire. Roentgenographic examination about twenty-four hours after the injury showed marked comminution and fragmentation of the right radius, the fragments describing an even arc. At operation, an aneurysm was found which had not been previously suspected.

The authors draw the following conclusions: (1) uniform deformity of a bone such as was seen in the roentgenogram should suggest the presence of an aneurysm; (2) the deformity achieves maximum size immediately after the injury; (3) the two lesions may be corrected at the same time.—*R. S. Bromer.*

BARNARD, LEONARD B., and MCCOY, S. MURRAY. The supracondyloid process of the humerus. *J. Bone & Joint Surg.*, Oct., 1946, 28, 845-850.

The presence of an anomalous spur, the authors state, on the medial aspect of the lower third of the humerus in approximately 1 per cent of people of European ancestry has long been known to anatomists, anthropologists and zoologists. However, its occurrence with a well defined clinical syndrome has received very little attention in the medical literature of the English-speaking countries. They report 3 cases together with a review of the anatomy and pathological findings discussed in the literature.

The supracondyloid process, when present, is often associated with a tendinous band, which is attached to the medial epicondyle, and with an anomalous origin of the pronator teres. It can cause a syndrome characterized by pain, radiating from the shoulder to the area of the median nerve of the hand. The pain is increased by pronation of the extended arm.

The diagnosis is easily made by palpation,

but routine anteroposterior or lateral roentgenograms may fail to show the spur, because of its position on the anteromedial aspect of the bone. An oblique view may be required to demonstrate it.

In resection of the bony spur, the authors emphasize the fact that removal of the periosteum of the spur and the binding fibers of the pronator teres should be done to prevent regeneration of the spur and the recurrence of symptoms.—*R. S. Bromer.*

URIST, MARSHALL R. Complete dislocations of the acromioclavicular joint; nature of the traumatic lesion and effective methods of treatment with an analysis of forty-one cases. *J. Bone & Joint Surg.*, Oct., 1946, 28, 813-837.

This paper is a very complete report and analysis of 41 cases of complete dislocation of the acromioclavicular joint. Mechanism of the injury, experimental observations, examination of resected joints, special tests of value during treatment, evaluation of symptoms, various methods of treatment, end results and complications and sequelae are discussed under separate headings.

In the summary of the paper, Urist states that calcification and ossification, observed with the aid of soft-tissue roentgenographic techniques, were found in the region of the conoid and trapezoid ligaments in approximately half of the series of 41 cases. He regards this phenomenon as a part of the healing of the ligaments. It is important to evaluate possible anatomical variations from the supposed normal joint structure which may determine the success or failure of conservative treatment and the incidence of sequelae. Complete dislocation may occur with, or more often without, gross rupture of the coracoclavicular ligaments. Excision of the outer end of the clavicle, used successfully in 9 cases of the series, is regarded as apparently the most uniformly successful method of treatment for both recent and old complicated acromioclavicular dislocations.

Two observations of possible and prognostic importance were noted in the course of the study, although the limited number of cases does not permit positive statements concerning them at this time: (a) An increase in the width of the joint space on the injured side, demonstrated roentgenographically, indicates posterior displacement of the outer end of the clavicle, even when the acromion process and

the clavicle are correctly aligned. (b) Palpable posterior displacement and abnormal mobility of the outer end of the clavicle, after three weeks of healing, indicate the probable failure of conservative methods and the recurrence of the dislocation.

In 2 cases of the series, so-called avascular necrosis or osteochondritis was observed. In both cases, subchondral fractures were found at open operation. Avascular necrosis is not frequent, but should be expected in severe cases, as demonstrated by the roentgenograms, whether or not reduction has been accomplished.

The paper contains a very complete bibliography.—*R. S. Bromer.*

FINCH, A. D., and ROBERTS, W. M. Epiphyseal coxa valga. *J. Bone & Joint Surg.*, Oct., 1946, 28, 869-872.

Two cases of epiphyseal coxa valga are reported. Many articles on epiphyseal coxa vara or slipping of the capital femoral epiphysis in adolescents, with a residual varus deformity, have been published since the latter part of the nineteenth century. Apparently, however, no case of epiphyseal coxa valga in the presence of a morphologically well formed acetabulum has been reported in the English literature, although Müller in 1926 reported the development of coxa valga with epiphyseal slipping in cases of hypoplastic, flattened, or almost vertical acetabula. The condition is not mentioned in standard textbooks. A study of 100 cases of slipped capital femoral epiphyses, treated at the North Carolina Orthopedic Hospital since 1921, disclosed only 2 patients with a valgus deformity. This apparent rarity of epiphyseal coxa valga warranted, the authors believe, the report of these cases.

The roentgenograms which are reproduced illustrate clearly the displacement of the capital femoral epiphyses with the coxa valga deformity. The authors draw attention to the fact that use of the conventional or Whitman type of reduction by forcible internal rotation is contraindicated, as it probably increases the displacement of the head of the femur and favors the development of avascular necrosis.—*R. S. Bromer.*

SOMERVILLE, E. W. Air arthrography as an aid to diagnosis of lesions of the menisci of the knee joint. *J. Bone & Joint Surg.*, July, 1946, 28, 451-465.

Somerville reports the study of a series of 331

examinations of the knee joint by air arthrography. The technique used combined the more important features described by previous workers. While the basis of the technique remained the same in all cases, many variations in detail were tried and improvements were made from time to time.

His technique is explained with excellent illustrations. The portion of the paper devoted to roentgenographic interpretation is also profusely illustrated with roentgenograms and specimens of menisci removed at operation. Examples of the various types of lesions are shown such as "bucket handle" tears, lesions of the anterior and posterior horns, persistent remnants of posterior horns, contused menisci, "tag" lesions, discoid menisci and "hypermobile" lesions.

Other lesions than those of the menisci can be demonstrated with less accuracy. Erosions of the articular cartilage are only demonstrable when the erosion is deep and extensive. In his series, only 2 cases of non-osseous loose bodies were shown. Osteochondritis dissecans can be seen more distinctly with air in the joint but in all cases the diagnosis had already been established by straight roentgenograms. Following air injections, the semimembranosus bursa can frequently be palpated clinically and has been found in a number of knees in which its presence had caused no symptoms. In one knee, a semimembranosus bursa was seen which contained a loose body.

Somerville concludes that in a large majority of injuries of the menisci, the diagnosis can be made on clinical grounds alone. Air arthrography is, however, useful as an aid to diagnosis, particularly in mixed lesions, such as tears of the anterior cruciate ligament associated with tears on the menisci, or simultaneous lesions of both menisci. The diagnosis of lesions of the medial meniscus is simpler than that of lesions of the lateral meniscus. Arthrography is of less value in the diagnosis of other lesions of the knee joint. It affords interesting information regarding the movements of the menisci during flexion and extension of the knee. These movements can be studied both with roentgenograms and by the fluoroscope. When the knee is flexed, the medial meniscus tends to be drawn backward out of the joint, and for this reason is not trapped.

Although the injection of air into a joint may produce a transient effusion, this is in no way harmful. Arthrography is a safe and simple procedure when done with full aseptic precautions.

Since the conclusion of the series, a technique has been devised for outlining the articular cartilage of the patella and the adjacent cartilage of the femoral condyles. The knee is filled with considerably more air than is used for other views. The compression bandage is applied above the knee, and the knee is flexed over the curved stand, illustrated in the portion of the paper on technique, to the greatest extent possible without obliterating the patellar tip. With an ordinary occlusal film pressed hard into the patellar ligament immediately above the tibial tuberosity, a roentgenogram is then made.—*R. S. Bromer.*

GURI, J. PUIG. Treatment of painful spondylolisthesis. *Surg., Gynec. & Obst.*, Dec., 1946, 83, 797-806.

In cases of painful spondylolisthesis a complete relief of the symptoms was obtained in 41.1 per cent of the patients treated conservatively and in 69.2 per cent of the cases treated by spinal fusion.

In no instance was a definite progression of the deformity observed after the treatment by means of braces or posterior spinal fusion had been undertaken.

Surgical procedures that endanger the life of the patient are not justified either from the view of the relief of the symptoms, or in order to check the progression of the deformity.

The presence of a sciatic pain associated with the local spinal symptoms does not necessarily mean that permanent relief cannot be obtained unless the disc is removed or curetted. In 55.5 per cent of the cases presenting such a clinical picture, complete relief was obtained either by conservative means or after the fusion of the posterior spine.

In advanced cases of spondylolisthesis the spontaneous fusion of the anterior spine after destruction of the intervertebral disc did not constantly produce complete relief of the symptoms. On the other hand, following the application of a spinal support or the surgical fusion of the posterior spine, all the symptoms disappeared.—*Mary Frances Vastine.*

HAAS, S. L. Fusion of vertebrae following resection of the intervertebral disc. *J. Bone & Joint Surg.*, July, 1946, 28, 544-549.

Opportunity for direct study of vertebral bodies after removal of the intervertebral disc is not available. Roentgenographic examination

may be inconclusive as minute changes are not discernible. It is known that bony fusion does not always take place after resection of the articular cartilage of other joints. Because study in animals seemed warranted, Haas performed a series of six experiments upon dogs.

Commenting on the results, he found that complete bony bridging occurred between the bodies of the vertebrae of dogs after the intervertebral discs had been removed. The bone proliferation was more active in young animals. When firm osseous union took place, the combined length of the two vertebrae which had been operated upon was less than before operation; when union was not completely osseous, there was no diminution in length. With bony union, buckling toward the spinal canal tended to occur, which might account for some loss of length. Haas feels that if a disc operation is performed upon a growing individual, the possibility of retardation of growth with resulting deformity of the spine should be taken into consideration.

He found that in removal of the disc from the abdominal side, there was evidence of injury to the dura and cord. Likewise, in the dorsal approach there was danger of injuring the large vessel on the abdominal side. After the intervertebral disc had been removed, there was no gross evidence of displacement of the articular facets. None of the operations were performed by the dorsal spinal approach, but nevertheless, Haas states that it can be predicated from the results of his experiments that, in dogs, if the disc is thoroughly removed so as to expose the bone on either side, osseous union will take place between the two bodies. The method of union is similar to that observed in the healing of fracture in a long bone.—*R. S. Bromer.*

LA CHAPELLE, E. H. Osteotomy of the lumbar spine for correction of kyphosis in a case of ankylosing spondylarthritis. *J. Bone & Joint Surg.*, Oct., 1946, 28, 851-858.

La Chapelle reports a case of a patient with ankylosing spondylarthritis on whom he performed an osteotomy of the lumbar spine for correction of a kyphosis. In his introduction to the paper he states that gradual or manipulative correction of kyphosis in cases of advanced ankylopoietic spondylarthritis has been widely employed for many years with discouraging results. Corrections have been uniformly incomplete. They were not without danger and

eventually the deformity almost always recurred. His patient's urgent wish to become erect and his otherwise healthy, vigorous condition promoted the author to devise a method of operative correction through section of both the anterior and posterior elements of the vertebral column. The operation, when performed on the cadaver, gave promise of being safe and feasible and it proved to be effective in achieving correction. He then successfully performed it upon the patient whose case is reported in this paper. Satisfactory correction was obtained without untoward incident and the result two years later was gratifying.

The operation was performed in two stages. The first involved the removal of the laminae of the second lumbar vertebra and of the posterior articulations between second and third lumbar vertebrae. The second stage of the operation was performed through an anterior approach, and consisted of the excision of the second intervertebral disc, correction of the angulation of the spinal column and fixing of bone grafts in the gap between the two vertebrae.

The paper is illustrated with roentgenograms of the spine before operation and the result shown at eleven and also twenty-five months after operation.—*R. S. Bromer.*

VAN DEMARK, R. E., and MCCARTHY, P. V. Panner's metatarsal disease; a condition of aseptic necrosis simulating march fracture. *J. Bone & Joint Surg.*, Oct., 1946, 28, 842-844.

Subperiosteal stratification of the distal shaft of a central metatarsal bone is generally regarded as roentgenographic evidence of a march fracture when it first appears, in the absence of distinct recent trauma, in a young infantry recruit who suffers with a painful foot. The authors note that a similar subperiosteal stratification may be associated with a varying degree of aseptic necrosis of the adult metatarsal head. Watson-Jones has pointed out the resemblance of the latter condition to march fracture. Although the name of Panner is associated with the condition of subperiosteal stratification, Köhler had previously described the thickening of the distal portion of the diaphysis. Freiberg's illustrations also showed thickening although this feature was not specifically discussed.

A case is reported with serial roentgenograms

illustrating the subperiosteal stratification with later somewhat cystic change in the head of the affected metatarsal. The differentiation of Panner's disease from march fracture is essential from both prognostic and therapeutic viewpoints. A certain rigidity and mild pain persist in the affected metatarsophalangeal joint as a result of aseptic necrosis of the metatarsal head. Patients with this condition do not respond to the ambulatory type of treatment which has proved satisfactory in most march fractures.—*R. S. Bromer.*

BONNET, W. L., and Baker, D. R. Diagnosis of pes planus by x-ray. *Radiology*, Jan., 1946, 46, 36-45.

This article is of particular interest to those radiologists who are working with orthopedists. It is pointed out that the diagnosis of pes planus can be made more accurately with properly taken and measured films than by clinical methods. The pedogram (footprint) does not give the true descent of the arch.

A lengthy discussion of the mechanism of the production of pes planus is given. The roentgenologic criteria of the condition are (1) an elongated second metatarsal as compared with the first; (2) broadening of the shaft of the second metatarsal as compared with the fourth; (3) increased separation between the internal and middle cuneiforms; (4) sesamoids over the middle metatarsal located proximal to the head.

The authors used the height of the outer longitudinal arch during repose and weight bearing. The amount of pronation was determined by a special double exposure made in the anteroposterior projection.

They conclude (1) that many persons having a normal appearing arch may have a basis for their symptoms if examined by the roentgen ray; (2) that "Morton foot" (short first metatarsal, etc.) may or may not co-exist with roentgen evidence of pes planus; (3) that pes planus is an important physical condition resulting in far reaching body changes and should be given more recognition by both radiologists and the general medical profession.—*J. H. Harris.*

BICKEL, WILLIAM H., and DOCKERTY, MALCOLM B. Plantar neuromas, Morton's toe. *Surg., Gynec. & Obst.*, Jan., 1947, 84, 111-116.

The affliction formerly called Morton's toe

or Morton's metatarsalgia has its pathologic basis in a tumefactive perineural fibrosis of the fourth digital nerve of the foot. Degenerative as well as proliferative nerve changes along with a neural and perineural edema are additionally present. The lesion may affect digital nerves other than the fourth, the predilection for which may be determined by anatomic peculiarities in composition. There is considerable evidence that trauma from weight-bearing in small or otherwise ill-fitting shoes is responsible for the pathogenesis of the lesion. In intractable cases the most promising treatment is resection of the affected nerve.—*Mary Frances Vastine.*

ROSE, E. K., GYÖRGY, P., and INGRAHAM, N.R., JR. Penicillin in the treatment of the syphilitic infant; progress report. *J. Pediat.*, Nov., 1946, 29, 567-584.

This report supplements a previous report on the use of penicillin in the treatment of syphilitic infants. The authors point out that syphilis is a severe and more serious infection in the infant than in the adult. In the former the infection is more intense, more massive and interferes with tissue growth.

Thirty-six cases of congenital lues have been treated by the authors with penicillin. Criteria for inclusion in the study include a high or rising titer by serology for syphilis, a characteristic macular eruption or roentgen evidence of metaphysitis with or without periostitis. Six of these 30 cases had no roentgen evidence of bone lesions. Details of the dosage and clinical response are given. In general, the osseous changes showed characteristic involution on serial films. In 3 cases dactylitis showed roentgen progression before regression.

In 2 cases of osteochondritis treatment resulted in rapid calcium deposition at and around the metaphysis as a result of the healing process. From the illustrative films it is apparent that actual shaft infarctions had occurred in these patients at the site of calcium deposition. In some infants rapidly progressive and destructive lesions became evident in the long bones under treatment. The authors compare this to similar changes occurring in acute progressive osteomyelitis. In each case rapid destruction of spirochetes or staphylococci occurs with elimination of necrotic debris followed by periosteal and soft tissue inflammatory reaction with subsequent osseous repair.

Recommendations are made as to total

dosage although optimum time dosage relationship has not been finally determined.—*Rolfe M. Harvey.*

CAFFEY, J. Infantile cortical hyperostoses. *J. Pediat.*, Nov., 1946, 29, 541-559.

The author has previously described 4 cases of this syndrome which is characterized by: (1) tender deep soft tissue swellings; (2) cortical thickening of the skeleton; and (3) onset during the first three months of life. Hyperostosis was found in the mandible, clavicles, scapulae, ribs, and the tubular bones of the extremities. The soft tissue swellings were in the approximate location of the skeletal changes.

Other occasional findings were fever, anemia and increased sedimentation rate. Recovery is spontaneous after weeks or months. The cause remains undetermined.

Caffey reports an additional 5 cases in this article. From these additional cases it is evident that the onset of the disease may be later than three months as originally reported. One of the present series had its onset at the tenth month and one at the twentieth month respectively.

Facial swellings were present in all 6 cases with an onset prior to the sixth month but not in those with a later onset. In 2 of the cases so far reported no fever has been detected during the course of the disease. There was no evidence of pleurisy in any of the 6 cases of the present series although it was present in 3 of the 4 cases originally reported. Pleurisy was noted in cases with extensive cortical rib thickening only.

It should be noted that there may be a lag of at least four weeks between the appearance of soft tissue swellings and evidence of roentgen changes in the bones.

In the differential diagnosis, periostitis, osteomyelitis and malignancy of the mandible, scurvy, poliomyelitis, leukemia and rheumatic fever must be considered.—*Rolfe M. Harvey.*

DICKSON, DOUGLAS D., LUCKEY, CLARENCE A., and LOGAN, NOBLE H. Infantile cortical hyperostosis. *J. Bone & Joint Surg.*, Jan., 1947, 29, 224-226.

A case of a full-term female infant is reported. The patient at the age of one week had orange juice and cod-liver oil included in its formula. At the age of two months, examination revealed a hard mass over the region of the right scapula with invasion of the right axilla. Roentgeno-

grams showed marked bony overgrowth of the right scapula with later involvement of the right clavicle. There was also considerable edema of the muscles over the right shoulder. Some cortical thickening of the mandible was demonstrated. Microscopic examination revealed invasion of the muscle with inflammatory cells. Final roentgen examination, nine months after the first observation, showed a normal bone pattern throughout the entire skeleton.

This case is similar to those reported by Caffey and Silverman who suggested the term, infantile cortical hyperostoses, for the syndrome.

The etiology in this case is obscure. Whether or not this patient showed a response to infection cannot be easily determined. The biopsy did not suggest that osteomyelitis was the cause. However, infants may respond differently than adults in the presence of a hematogenous osseous inflammatory lesion. It has been noted frequently that osteomyelitis in the infant is benign and produces no sequestra.—*R. S. Bromer.*

MACKENZIE, WILLIAM. Painful, non-suppurative, localized sclerosis of the long bones. *J. Bone & Joint Surg.*, Jan., 1947, 29, 49-58.

Two cases of painful, non-suppurative, localized sclerosis of long bones are reported. In each case a tibia was involved. The special feature of the case was the fact that the radiolucent area within the dense sclerotic portion was not sharply defined. In this respect the roentgenograms resembled those reported by Jaffe and Lichtenstein as osteoid osteomas. On microscopic examination the bone focus in the second case which was removed resembled the histopathological description of those writers.

Mackenzie expresses no opinion regarding the essential nature and cause of the lesion in both cases. The paper contains a short review of the literature of the sclerosing osteomyelitis of Garré and of osteoid osteoma.—*R. S. Bromer.*

GILLESPIE, H. W. The significance of minor bone injuries. *Brit. J. Radiol.*, May, 1946, 19, 173-177.

In fractures, injury to the ligaments and muscles is often equal in importance to the bone damage. In many cases of minor fracture, it is evident that the importance of the damage to the soft tissue actually outweighs the bone injury. These fractures are commonly described as chip fractures or detachments of a small bone

flake. The indirect diagnosis of "damaged ligament" rests on the fact that when the bone attachment of a ligament has undergone a strain, it rarely happens that the ligament is stripped off at the insertion, but that the ligamentous fibers are so firmly rooted in the bone that invariably a small bone fragment is avulsed. The attachment of the ligament remains intact, but the bone is broken.

The author describes and tabulates small chip fractures due to ligamentous damage as to the site of bone damage and the ligament affected. He similarly tabulates chip fractures due to avulsion of muscle and its tendons where the osseous damage equals or outweighs the soft tissue injury. Only a few of the more common injuries have been selected from the author's tables and listed below.

Bone Damage at:	Affected Ligament
1. Base of distal or middle phalanx of finger	1. Capsular interphalangeal ligament
2. Dorsal surface of os triquetrum or lunate	2. Posterior radiocarpal ligament
3. Styloid process of ulna	3. Medial ligament of wrist
4. Dorsal surface of tarsal navicular bone	4. Tibionavicular fasciculus of deltoid ligament
5. Dorsal surface of head of talus	5. Anterior talotibial fasciculus of deltoid ligament
6. Dorsal surface of neck of talus	6. Anterior capsular ligament
7. Lower border of medial malleolus	7. Deltoid ligament
8. Styloid process of fibula	8. Lateral ligament of ankle
9. Lateral margin of tibia	9. Inferior tibiofibular ligament
10. Tibial spine	10. Anterior cruciate ligament
11. Tibial plateau	11. Post cruciate ligament
12. Avulsion fracture of posterior angle of base of terminal or middle phalanx of finger.	12. Tendon of extensor digitorum

—*K. K. Latteier*

KLINEFELTER, EDMUND W. Ossification associated with chronic strain of the tibial collateral ligament from roller-skating. *J. Bone & Joint Surg.*, Jan., 1947, 29, 237-240.

Chronic strains of the upper half of the tibial collateral ligaments, which often occur among football players and skiers, do not result from the usual skating movements, but are produced by such movements as the "split" in figure skating. Subsequent to these strains, ossifications may develop in this part of the ligament. Similar ossifications, resulting from causes other than roller-skating, have received considerable discussion under the heading of Pellegrini-Stieda's disease. They have, in principle, the same significance and require the same treatment as those in the lower half of the ligament. The ossifications frequently produce symptoms and may interfere seriously

with the function of the attached ligaments and tendons.

The chronic strains are especially predisposed to develop in the obese woman with a square torso, protruding abdomen, and relatively long, thick legs, as she advances beyond the age of thirty-five years. In order to avoid collisions on crowded rinks, she is compelled to check her advance frequently, not by turning or gliding movements, but by throwing her weight on the inside wheels of the externally rotated skate as it is dragged against the floor; the same leg is practically always used for this purpose. Tremendous strain is thereby placed on the tibial attachments of the tibial collateral ligament, and of the popliteus and soleus muscles.

The development of the strain is gradual; the first symptoms rarely appear before at least three years of skating. A roentgenogram may show swelling of the tibial collateral ligament. Later osseous deposits are shown.

Roentgenograms are shown of 4 cases all of which occurred in women between forty-two and fifty-three years of age and with histories of roller-skating for periods ranging from twelve to thirty-one years. Osseous deposits and calcifications are shown in the medial collateral ligament.—*R. S. Bromer.*

SELIGSON, FRANK. Poncet's disease; clinical observations on inflammatory and degenerative joint reactions in tuberculosis. *Am. Rev. Tuberc.*, Dec., 1945, 52, 463-473.

The disease described by the author is based on two published books (Poncet, A., and Leriche R. *Le rhumatisme tuberculeux*. O Doin et Fils, Paris, 1909, 37-38, 40-41) (Poncet, A., and Leriche, R. *La tuberculose inflammatoire*. O. Doin et Fils, Paris, 1912). Poncet and Leriche call their clinical entity tuberculous rheumatism and describe numerous extrapulmonary conditions in the joints and other serous surfaces as being caused by the tubercle bacillus. They did not claim to find in all their cases the classical proof of tuberculosis, which means the positive guinea-pig test on inoculation and the typical pathological anatomical picture. They maintain that tuberculous rheumatism is only a clinical observation and state that while some of their cases meet the customary clinical requirements for the diagnosis of tuberculosis, very often the circumstantial evidence of clinical factors is considered as satisfactory proof of the tuberculous origin of the arthritic

lesion. They were of the opinion that bacillary toxins cause the different types of tuberculous rheumatism.

Eight cases are reported in this paper which are believed to support Poncet and Leriche's observations. The author believes that the use of tuberculin treatment should have a new trial.—*James J. McCort.*

KRAUSS, RUTH F. Osteomyelitis caused by salmonella typhimurium. *J. Bone & Joint Surg.*, Jan., 1947, 29, 227-232.

The case reported is that of a white boy two and a half years old, suffering from septicemia caused by the *Salmonella typhimurium* and complicated by osteomyelitis of most of the ribs, the scapula, pelvic bones and femur. There was no sequestration in any of the lesions, and the architecture of the bones returned to normal much more rapidly and completely than in the ordinary case of osteomyelitis caused by the staphylococcus. Leukopenia was present at the onset of the illness. Agglutinins developed in fairly high titer (1 to 800) against the offending organism. *Salmonella* organisms were not recovered from the feces, urine or pharyngeal secretions.

Salmonella typhimurium was found in the blood culture and was also recovered from a culture of the material obtained by biopsy from the ilium. The histopathological examination of the biopsy specimen showed a very extensive osteitis and osteomyelitis.

In view of the repeated finding that salmonella osteomyelitis often is a relatively mild disease so that it may improve without surgical intervention, the author suggests that such cases may have escaped diagnosis. In the future it may be wise to examine roentgenographically the skeletons of patients suffering from salmonella septicemia, in order to determine the true incidence of salmonella osteomyelitis.—*R. S. Bromer.*

SHERMAN, MARY S., and PHEMISTER, D.B. The pathology of ununited fractures of the neck of the femur. *J. Bone & Joint Surg.*, Jan., 1947, 29, 19-40.

This paper is a review of the pathological changes seen, following ununited fractures of the femoral neck. Nine cases are tabulated with histories, illustrations of roentgenograms and gross and microscopic specimens. The following are the authors' conclusions and summary:

1. The incidence of non-union is disproportionately high in intracapsular fractures of the neck of the femur, except in those which are either impacted or treated by accurate reduction and internal fixation. Factors entering into this high incidence are the frequent occurrence of death of the head fragment from disruption of the blood vessels of the neck, displacement of the fragment ends, poor immobilization, and failure of peripheral callus formation due to absence of a cambium layer on the neck.

2. If the head fragment survives, it undergoes atrophy of disuse of the same degree as that of the distal fragment, and the two fragments are of equal density on the roentgenogram. Treatment to produce union is usually successful and extensive degenerative changes in the joint do not occur.

3. If the blood supply to the proximal fragment is severed, so that the head dies, disuse atrophy cannot occur, and the head eventually appears on the roentgenogram to be more dense than the surrounding atrophic, living bone. As slow invasion of the head by vascular fibrous tissue occurs, with absorption of the necrotic bone and replacement by cancellous new bone, the roentgenogram shows areas of reduced density.

4. The necrotic articular cartilage remains relatively unaltered until a blood supply reaches it, when it is replaced either by an imperfect type of fibrocartilage or in part by bone.

5. Transformation of a dead head takes place first at the margins of the fracture and at the fovea, and the advancing replacement zone is the weakest part of the bone. Pathological fracture between the dead and living portions may result in collapse and delayed union or non-union.

6. If union has occurred, either primarily or as the result of surgical intervention in the presence of a dead head, and if weight-bearing is begun before replacement is complete, the head will probably collapse, and degenerative changes will be severe on both sides of the joint. If the head is adequately protected, it may be transformed without any collapse; the degenerative changes in the joint are minimal; and a good functional result is obtained.—*R. S. Bromer.*

LEVEUF, JACQUES. Primary congenital subluxation of the hip. *J. Bone & Joint Surg.*, Jan., 1947, 29, 149-162.

In cases of congenital dislocation, the author states that the French, contrary to the Anglo-Saxon authors, distinguish between luxation and subluxation. In the latter, according to recognized authorities, the head of the displaced femur remains in contact with a more or less deformed acetabulum. The importance of this distinction is even greater than was formerly thought. Leveuf's studies have shown that the primary subluxation of the hip presents some anatomical characteristics distinctly different from those of luxation. He has used arthrography, injection of the joint space with an opaque medium, since 1935, and he believes that this enables one to distinguish a subluxation from a luxation without difficulty, even in the youngest child.

Reduction by the closed method of a subluxated hip presents no great difficulty but in spite of orthopedic treatment, the articulation remains incongruent, and sooner or later, signs of a deforming osteoarthritis appear which eventually becomes a permanently disabling condition. The prevention of this forms the subject matter of this paper.

In the paper only primary subluxations are considered. The so-called residual subluxations which are sometimes observed after attempted bloodless reduction of true luxation of the hip, are quite different. They are characterized by the presence of interposed soft parts (limbus, round ligament and capsule) between the head and the acetabulum. Such interposition never occurs in primary subluxation.

The essential difference between subluxation and luxation is indicated by the position of the cartilaginous roof, formed by the union of the non-ossified part of the acetabular rim with the cotyloid fibrocartilage (also called the limbus). In a subluxation the limbus is forced upward and inward toward the iliac fossa; in a luxation the limbus is forced downward and inward toward the acetabulum. The worn down or shallow acetabulum is characteristic of subluxation, and not of luxation as is stated in orthopedic textbooks. In subluxation, the femoral head is deformed very early. In luxation, on the other hand, the head retains its regular contour for a long time. In subluxation the capsule, although enlarged, is never interposed between the femoral head and the acetabulum. In luxation, the capsule often is interposed between the head and the acetabulum, especially at the lower portion of the cavity. In subluxation, a valgus

deformity of the neck is often found. There is also anteversion of the neck. In luxation, there is no valgus of the neck. The anteversion is only found in very young subjects.

In regard to treatment, the author emphasizes that bloodless reduction must be checked rigorously by arthrography. The most favorable age for open reduction is around three years. The operation can be done on older subjects (fifteen years and over) provided the components of the articulation have not been deformed, especially by untimely orthopedic manipulations.

The roentgenograms which are reproduced demonstrate the use of arthrography. The solution used is a concentration of 30 per cent of ténébryl. This is identical with that used in urography and is rapidly eliminated, in approximately thirty minutes, without affecting the articulation. In conclusion, the author states that the articular surfaces must be in perfect alignment (perfectly congruent). This is the only way to prevent a later deforming osteoarthritis. Only by arthrography can one visualize in the roentgenogram the state of the soft parts, namely, the cartilage of the roof, the limbus and the capsule.—*R. S. Bromer.*

BACHMAN, A. L. Roentgen diagnosis of knee-joint effusion. *Radiology*, May, 1946, 46, 462-469.

In the study of roentgenograms of knees of patients admitted to Station Hospital, Miami Beach Training Base, changes in soft tissues have been noted which have facilitated the diagnosis of effusion into the knee joint.

A description of the roentgen anatomy of the knee is given and, based on the anatomical considerations, the following roentgenographic signs were found:

1. A widened band of fluid density (the distended base of the suprapatellar pouch) in the lower portion of the area of fatty radiolucency between the posterosuperior angle of the patella and the femoral condyle. This is the most reliable sign.
2. Anterior pressure convexity, mainly of the upper half of the infrapatellar fat pad.
3. Complete or nearly complete delineation of the pyriform fluid-filled suprapatellar bursa (in those cases where the bursae are surrounded by a thin rim of fatty tissue).
4. Anterior displacement of the patella.

5. Widening of the knee joint. In the 20 cases listed, in no case was distinct widening of the knee joint observed.—*F. B. Markunas.*

GURI, JOSE PUIG. The formation and significance of vertebral ankylosis in tuberculous spines. *J. Bone & Joint Surg.*, Jan., 1947, 29, 136-148.

In reviewing the cases of tuberculous spondylitis, the author noted that in a few cases the clinical healing of the process coincided with the roentgenographic appearance of a spontaneous fusion of the anterior spine. In the cases where a prolonged roentgenographic follow-up was available, it was observed that these vertebral synostoses, or vertebral blocks, had been formed either by end-to-end contact of two or more vertebral bodies after destruction of the intervertebral disc and cartilaginous plates, or by recalcification and union of the remnants of several vertebral bodies which had been partially destroyed during the early stages of the disease. The amount of concurrent deformity of the spine, and shape, structure, and speed of formation of these synostoses, were not uniform.

Careful study of the spines which healed by the formation of vertebral synostoses showed that three main factors regulated the speed of their formation and final configuration: the topographical distribution of the infection, the pathomechanics of the different spinal segments, and the treatment. The different sources of blood supply to the different parts of a vertebral body explains the different topographical types which Guri, in spite of the complex variety of names suggested, basically reduces to three: anterior, central and epiphyseal. The formation of a vertebral synostosis is possible, in the great majority of cases, only after the approximation and superimposition of the affected vertebrae. This approximation can be performed either along a longitudinal axis (telescoping), by flexion in the sagittal plane of one spinal segment upon the other, or, in a minimum number of cases, by flexion in the frontal plane (the so-called tuberculous scoliosis). In the lumbar region a marked amount of telescoping may occur while it is minimum in the thoracic area. Forward flexion is most frequent in the thoracic region. Another factor that influences the final shape of the vertebral synostosis is the appearance of protective muscle

spasm. This produces, from the onset, a complete flattening of the lordosis in the lumbar spine, thus allowing uniform telescoping of the vertebral bodies in cases of the epiphyseal type. The amount of destruction that takes place in each vertebral body, the number of affected bodies, and the type of treatment are also factors influencing the final shape of the synostosis.

The formation of vertebral synostoses in tuberculous spondylitis in adults is discussed, first in cases of so-called epiphyseal spondylitis, and second in cases of central tuberculous involvement. Roentgenograms showing the types are reproduced. A section is also devoted to tuberculous spondylitis in children. Guri notes that in children, the division between epiphyseal and central types was not as definite as in adults. It was not infrequent to observe cases in which a primary epiphyseal infection extended far inside the vertebral body. It was much more common to observe involvement of several contiguous vertebral bodies than in adults. The number of cases in which a block could not be obtained was much higher in children than in adults.

In his conclusion, Guri states that the effects of a given treatment upon the evolution of a tuberculous spondylitis cannot be properly evaluated unless the different topographical types of tuberculous spondylitis, the number of infected vertebrae, the pathomechanics of the different spinal segments, and the alterations in the structure of the vertebral body produced by the infection are taken into consideration. Only after consideration of all these factors is it possible to understand why in some cases sound healing may take place in one and a half to two years after the onset of symptoms, while in other cases the process continues to progress for longer periods of time.—*R. S. Bromer.*

GILLESPIE, H. W. Radiological diagnosis of lumbar intervertebral disc lesions. *Brit. J. Radiol.*, Oct., 1946, 19, 420-428.

There are several objections to the use of contrast medium in the diagnosis of intervertebral disc lesions: it is time-consuming; it is unpleasant to the patient; it is possibly dangerous by the production of arachnoiditis in some patients; a negative examination does not exclude the possibility of a small protrusion; and lesions other than a disc protrusion, such as

hypertrophic ligamentum flavum, may produce a persistent defect in the opaque medium used. A statement of Dandy is given contending that a combination of symptoms, signs, and plain roentgenograms without myelography permits accurate diagnosis in 98 per cent of patients in whom defective discs cause backache with or without sciatica. The straight roentgen examination of the lumbosacral spine is not only valuable as an aid in confirming a clinical diagnosis, but Dandy believes that that examination alone can make the diagnosis in more than 50 per cent of cases.

The author presents evidence from 160 cases which were examined with straight roentgenograms and which were subsequently subjected to operation. The roentgen examination of the lumbosacral spine was normal in one-third of these. The other two-thirds showed changes which were interpreted as confirming the clinical diagnosis of a protruded disc. These findings were grouped as follows:

1. Narrowed cartilage space between two vertebrae.
2. Hypertrophic fringe formation.
3. Congenital anomalies.
4. Loss of lumbar lordosis.
5. Lumbar scoliosis.

In 31.2 per cent the first two elements were found to aid in showing the existence and localization of the disc. In older individuals narrowing may represent simple osteoarthritic change, but in individuals under forty years, the finding becomes more significant. Certain congenital anomalies, such as spina bifida, or spondylolysis may reduce structural stability, and this favors prolapse of a disc if trauma has occurred. The author attaches much less significance to abnormal curvatures of the spine than to the other elements mentioned.

In addition to the routine anteroposterior, lateral and oblique views, several other projections are suggested. These include examination with the patient upright, detail views with the central ray directed through the space to be investigated, and particularly, close-up technique, which is valuable in showing early osteoarthritic changes.

Emphasis is placed on the concept that a diagnosis can be based on typical clinical symptoms and signs with roentgen changes which would confirm these as to nature and location of

the lesion. The author feels that myelography is unnecessary.—*E. F. Lang.*

BLOOD AND LYMPH SYSTEM

KING, DAVID J. A case resembling hemangiomatosis of the lower extremity. *J. Bone & Joint Surg.*, July, 1946, 28, 623-628.

King reports a case which presents a problem in diagnosis. He could find no report of a similar case. The microscopic picture of the lesion suggested that it involved the capillary system and he selected the title of this report for this reason. On gross examination, however, no extraneous blood vessels were encountered. Although both bone and soft tissue were involved, the primary lesion appeared to surround the great vessels of the limb.

The patient was an eleven year old white boy who fell from a bicycle and injured his left knee. Roentgenograms made one, and again three months later showed no involvement of bone. One year later he was admitted to the hospital for generalized swelling of the left lower extremity with discoloration above the knee, elevation of the skin temperature and with a fluctuant wave involving the thigh and upper half of the leg. Roentgenograms showed marked soft tissue swelling and destruction of bone in the distal third of the left femur. It was decided to examine the lesion at operation and amputate the limb. The microscopic sections were examined by four pathologists who considered the lesion to be some type of angioma. The suggestion was made that the changes found in the sections were associated with disease (anomalous or otherwise) of the general vascular system of the leg. The wound after operation healed per primam but the bogginess of the stump which developed continued for some time. Roentgenograms after operation (approximately seven months later) showed decreased calcification and punched-out areas in the remaining portion of the femur and in the acetabulum. Roentgen therapy was employed and was discontinued about a year after operation. Two years after operation the bogginess of the stump had disappeared and roentgenograms showed progressive improvement. It was felt that roentgen therapy was no longer needed. At the time of the writing of this report, the patient was being followed in the clinic.—*R. S. Bromer.*

ROENTGEN AND RADIUM THERAPY

ROBBINS, L. L., AUB, J. C., COPE, O., COGAN, D. G., LANGOHR, J. L., CLOUD, R. W., and MERRILL, O. E. Superficial "burns" of skin and eyes from scattered cathode rays. *Radiology*, Jan., 1946, 46, 1-23.

This article reports the varying degrees of injury received by six men in the Department of Radiology of the Massachusetts General Hospital as a result of a few seconds' exposure to scattered electrons from a 1,200 kv. electrostatic generator. This report is of importance to those working with supervoltage generators. There are no previous reports in the medical literature of injuries due to scattered cathode rays.

Because of a wandering focal spot on the supervoltage treatment machine, the target was renewed and a cathode-ray window inserted. With the latter window in place the focal spot could be located by inserting a film beneath the window and burning a hole in it with very short exposure.

Six men were in the room while the machine was running not longer than two minutes. Each of the six stood at least 3 to 5 feet or more feet away from the central beam and at right angles to it. At one point all leaned down and for five seconds looked at the cathode-ray window.

After it was apparent that these men had received burns, ionization measurements were made to determine the dose and depth of penetration of the radiation received. It was determined that those who stood 100 cm. from the cathode port for twenty seconds received a skin dose of about 1,000 r on their faces and 2,000 r on their hands.

It appears logical to expect that the effect of a given tissue ionization dose will be the same for a 1,000 kv. cathode ray as for roentgen rays of similar wavelength, since the ionization from roentgen rays is largely produced by secondary electrons with velocities approaching those and the electrons striking the target, and the damage to the tissues is also probably due to the effects of these electrons or the ions they produce.

The article gives detailed descriptions of the extent of the burns each man received.—*J. H. Harris.*

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 59

APRIL, 1948

No. 4

EFFECTS OF RADIOACTIVE SODIUM ON LEUKEMIA AND ALLIED DISEASES

PRELIMINARY REPORT*†

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RADIOACTIVE sodium has not been used extensively in therapy of generalized neoplastic disease, primarily because it does not tend to be concentrated in the regions of rapid growth as does phosphorus. The results with radioactive phosphorus, however, indicate that the localization is not sufficient to permit complete destruction of the pathologic cells without damaging adjacent normal cells.^{8,9,10,16} These recent reviews also conclude that although P^{32} appears to be an excellent therapeutic agent for polycythemia vera, and its effects on chronic leukemias are about the same as with roentgen therapy, some conditions do not respond as well as with roentgen rays (Hodgkin's disease, lymphosarcoma, reticulum cell sarcoma and multiple myeloma). It is also indicated that P^{32} therapy, as well as roentgen radiation, is unable to control cases of acute or subacute leukemias. Unfavorable reactions that sometimes occur in radiophosphorus therapy are production of leukopenia, thrombocytopenia, anemia, and aplasia of bone marrow. Since there is considerable variation in susceptibility of

different subjects, dosage must be individualized to a high degree. It is necessary to study the condition of the blood at frequent intervals so that administration can be stopped before irreversible toxic effects on the bone marrow are produced.

Compared to these difficulties in the administration of P^{32} , radiosodium offers some possible advantages. The irradiation, from a single dose of Na^{24} is not as prolonged (half-life is 14.8 hours) as with P^{32} , and it is therefore easier to regulate the dose and frequency of treatment to fit the immediate and individual need of the patient. Also, the excretion of Na^{24} is not as great or as variable as in P^{32} therapy.^{1,4,5,6,7,11,12,13,18} Although the P^{32} uptake of some tissues is rapid, the more desired localization within growing cells is not appreciable until several days after the administration. By this time, a considerable amount of general radiation has been delivered, and the total P^{32} content has been reduced by elimination and decay. As the beneficial response of leukemias to radiation is due to the greater radiosensitivity of the abnormal cells, radiosodium therapy should produce bene-

* This investigation has been aided in part by a grant from American Cancer Society.

† Presented at the Twenty-ninth Annual Meeting, American Radium Society, Atlantic City, N. J., June 9-10, 1947.

ficial effects even though its distribution is general.

Radiosodium therapy has some advantage over the usual roentgen treatment in that it includes the entire body, is protracted over a two day period, and the radiation is relatively more intense in the blood and other body fluid. The gamma radiation of the Na^{24} provides general irradiation whereas its beta radiation produces a more localized treatment of organs containing larger amounts of body fluid.

The possibility of using radiosodium in therapy of leukemias was first investigated by Hamilton and Stone.^{4,6,7} Two patients were treated for a period of approximately two weeks and information was gained regarding the distribution and elimination of the material. At the end of the two weeks' period, neither patient had suffered any ill effects but the disease had failed to respond. It was felt that sufficient time had been allowed for the experiment and a course of roentgen therapy was given. Later, a study of effects of radiosodium on normal and leukemic mice was made by Evans and Quimby.² The effects on the blood and on viability were similar to that of whole body roentgen irradiation and a ratio of effectiveness of the two types of irradiation was determined for the mice. Animals with enlarged nodes and extremely high leukocyte counts were especially sensitive to the radiosodium. Studies of distribution indicated that the marked response was due to radiosensitivity of the abnormal leukocytes rather than to any selective concentration in lymph nodes. The results of this investigation, together with the considerations mentioned above, encouraged the present writers to investigate more fully the possibility of treating leukemia in man with radiosodium. Thygesen, Videboek and Villaume have also been making such a study and in 1944 published a preliminary report¹⁷ in which it was indicated that some patients had responded favorably at least for a time. We started the investigation in 1944, but progressed slowly as several limitations restricted treatments to one or two per week. Thirty-one patients

have been treated and in 24 enough information has been gained to permit a few tentative conclusions to be made at this time.

MATERIALS AND METHODS

We are indebted to the staff of the Cyclotron Laboratory of the Physics Department of Columbia University for the radioactive sodium, Na^{24} which we used in this investigation. The sodium was delivered as an approximately isotonic solution of sodium chloride. Duplicate samples were taken, diluted, and measured for activity (microcuries per cubic centimeter) with a Geiger counter which had been suitably calibrated and checked with proper standards.*

Radioactive isotopes are measured in terms of curies (1 millicurie = 37,000,000 disintegrations per second). One would not expect that a millicurie of P^{32} would exert the same biological effect as a millicurie of Na^{24} . The radiation dose delivered by a millicurie of P^{32} is about eight times that of one of Na^{24} , but of course the P^{32} dose is protracted over a longer period of time (for determinations of doses see references 11, 14 and 15).

Because of the penetrating radiation emitted by the radiosodium (1.4, 2.8 mev gamma and 1.4 mev beta), it was necessary to use heavy lead protective shielding. Precautions were taken so that the exposure to personnel was always well below 0.1 r per eight hours. Approximately 50 millicuries were available each week and this was administered by mouth as a solution of sodium chloride (less than 1 per cent) and, especially when further diluted, was tasteless. It was given in two or three small lots, ten to fifteen minutes apart, and was followed by an equal volume of water in order to rinse the mouth, etc.

No rigid plan of treatment was adhered to other than an attempt to reduce the symptoms with a series of treatments and to give an occasional dose thereafter as in-

* We wish to express our appreciation to Dr. Edith H. Quimby for supervision of these standardizations, and to Miss Charlotte Schmidt who made most of the pre-treatment measurements.

dicated. The first treatment was considered as a test dose and was usually less than 180 microcuries per kilogram of body weight. Subsequent doses were regulated according to the need and sensitivity of the individual.

Blood counts were done every few days after the first dose and if there had been no response in a week or two the treatment was repeated. A complete blood count was done before each treatment and the blood was checked a week later. The frequency

enous (Case 13), and one lymphatic (Case 21), died of leukemia about forty-eight hours after radiosodium had been administered. Several tissues were taken at autopsy and determinations were made of their radioactivity. The activity remaining in the entire body at this time was estimated and this, divided by the body weight, gave an average value with which the individual tissues could be compared. The results are shown in Table I. There was no marked concentration of the radiosodium

TABLE I
ACTIVITY PER GRAM, WET WEIGHT, OF MATERIAL RELATIVE TO THAT OF ENTIRE BODY

	Skin	Adrenal	Cervical Lymph Node	Mesenteric Lymph Node	Spleen	Small Intes- tine	Liver	Kidney	Muscle	Verte- bra
Case 13	1.24	0.98	1.30	1.00	1.00	0.59	1.83	1.44	0.75	1.84
Case 21					1.25		1.25	1.75	0.62	2.75

and completeness of the counts during the period of control was regulated according to the apparent need. In subacute and acute cases, daily blood counts were done.

RESULTS

I. *Excretion Studies.* It was found, in agreement with the results of Hamilton and Stone,^{4,6,7} that the amount of radiosodium excreted was less than 10 per cent of the administered dose. Actually the mean value for twenty determinations (7 patients) was 2.3 ± 1 per cent for the first twenty-four hours. In terms of administered radiation, this loss was negligible. The percentage excreted appeared to be related to the individual patient rather than to amount of radiosodium administered or to the amount of urine excreted. In only one patient did the percentage of radiosodium excreted increase in proportion to the amount of urine. The largest amount of excretion (average of 5 per cent in five tests) occurred in a young boy of six with acute lymphatic leukemia.

II. *Distribution of Radiosodium in Tissues of Patients.* Two children, one myeloge-

dium although the content was somewhat higher in the vertebra, liver and kidney, and was slightly lower in muscle and intestine. This is in general agreement with results of previous investigations.^{2,3,14}

III. *Preliminary Therapeutic Study.** The first patients on whom we attempted radiosodium therapy were: a patient in the terminal stage of Hodgkin's disease (Case 1), 3 patients in the terminal stage of lymphosarcoma (Cases 2, 3 and 4), and a patient in the terminal stage of myelogenous leukemia (Case 5). All of these patients were not being benefited by further roentgen therapy. Only a few small doses of radiosodium were given as the condition of the patients was critical. The unfavorable trend was not stopped, but each treatment was followed by relief of pain and temporary regression of symptoms. The results encouraged us to continue our studies, but it was decided to concentrate our efforts at first on the treatment of chronic leukemias

* These were patients of Dr. J. H. Farrow whose interest and cooperation was of great help in the early days of this undertaking, and we take great pleasure in acknowledging our indebtedness to him.

in order to have objective and quantitative criteria (changes in the blood) to enable us to estimate the relation between dose and effect.

IV. Chronic Myelogenous Leukemia.

(a) Patients with Previous Radiation Therapy. Three patients (Cases 6, 7, and 8) had been treated with roentgen radiation for about a year when they were selected for radiosodium therapy. One of these

141st day), he noticed some discomfort but indicated that it was very mild in comparison with the reaction he had formerly noted following adequate roentgen treatment. Additional data regarding these patients are shown briefly in Table II and in the case histories which follow.

CASE 6. This patient is a male, aged twenty-five, weighing 90 kilograms. The spleen and liver were not enlarged at beginning of radio-

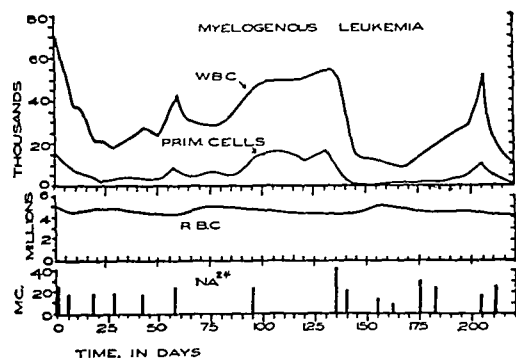


FIG. 1

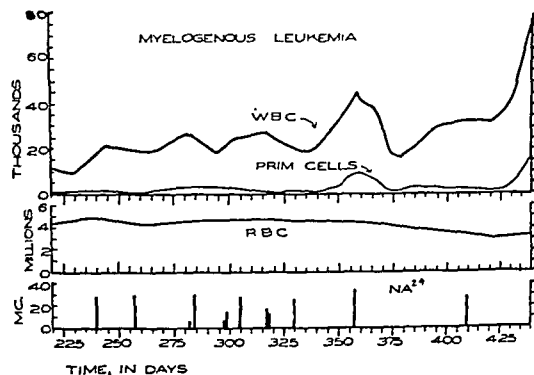


FIG. 2

FIGS. 1 and 2. Case 8. Myelogenous leukemia. "Primitive cells" = leukocytes \times percentage of myelocytes and myeloblasts. For further details, see text and Table I. On the 370th day 75 r was given over the spleen. Again on the 425th day 25 r was given over the spleen.

(Case 6) had been controlled with moderate amounts of roentgen radiation. He also responded well to the radiosodium therapy. The second patient (Case 7) had never been completely relieved of symptoms and following even heavy roentgen treatment the remission was of short duration. Nausea and discomfort occurred when enough roentgen radiation was given to reduce the leukocyte count. Doses of more than 20 millicuries of radiosodium were required every two or three weeks to keep the leukocyte count within normal limits. It was possible, however, to control the symptoms fairly well for about a year without producing any discomfort. The third patient (Case 8) had complained of radiation sickness and finally refused further roentgen treatment. Reduction of symptoms (see Fig. 1 and 2) without radiation sickness was possible with Na^{24} but frequent treatment was necessary. Following the heaviest treatment (40 millicuries on the 135th day and 20 millicuries on the

sodium therapy. The minimum leukocyte count following Na^{24} treatment was 5,500. This remission lasted forty days. He was given twelve treatments (255 millicuries) over a period of ten months. His present condition is unknown to us.

CASE 7. This patient was a male, aged thirty-two, weighing 88 kilograms. At beginning of Na^{24} therapy, the liver and spleen were not enlarged but the leukocyte count had increased from 25,000 to 41,000 within a few days and the patient was not feeling well. Twenty-five treatments were given over a period of 353 days (576 millicuries). At the end of this time, indications of the terminal stage were an increase in myelocytes and myeloblasts (mostly basophilic), anemia, and splenomegaly. Frequent transfusions, supplementary roentgen therapy and other medication were ineffective and he died about a year after beginning the the radiosodium therapy.

CASE 8. This patient was a male, aged forty-five, weighing 80 kilograms. At beginning of radiosodium therapy the patient was weak and uncomfortable. The lymph nodes, liver

and spleen were palpable. He received thirty treatments (455 millicuries) over a period of 546 days (see Fig. 1 and 2). During treatment there was remission of symptoms and the patient was able to continue his usual activities. The best response occurred on the 162nd day after beginning of treatment when the leukocyte count was 9,500, the spleen was greatly reduced

(b) Patients with no Previous Radiation Therapy. Four such cases have been treated with radiosodium. One of these (Case 9) has responded very well and has been practically free of symptoms for 532 days. Another (Case 10) has been treated for 125 days and also appears to be easily controlled by

TABLE II

HEMATOLOGIC DATA ON PATIENTS WITH MYELOGENOUS LEUKEMIA
Blood counts (a) before Na^{24} treatment, (b) during treatment, and (c) at present,
or at end of treatment period

Case	WBC	Myelo- blasts	Myelo- cytes	Neutrophiles			Lym.	Other WBC	RBC (mil- lions)	Hgb (gm./100 cc.)	Platelets (thousands)
				juv.	bands	seg.					
6 (a)	19,100	0%	0%	0%	2%	78%	18%	2%	5.37	15.6	Good
(b)	12,700	0	0	0	3	68	19	10	5.10	15.3	Good
(c)	11,600	0	0	1	4	66	23	6	4.11	15.0	350
7 (a)	26,000	0	2	1	4	78	5	10	5.4	15.6	Good
(b)	12,750	0	0	0	2	79	9	8	4.4	15.0	Good
(c)	151,000	36	33	4	1	21	0	5	2.37	6.0	Very low
8 (a)	69,000	0	20	2	24	47	1	6	4.9	14.2	Good
(b)	9,500	0	6	2	3	69	7	13	4.8	13.0	Good
(c)	187,000	37	20	9	7	25	2	0	2.3	7.0	Low
9 (a)	266,000	1	21	11	33	28	1	5	4.20	12.2	142
(b)	17,000	0	2	3	34	44	6	11	4.85	15.0	152
(c)	18,000	0	11	1	12	52	24	0	5.36	17.0	227
10 (a)	96,000	1	23	12	21	34	5	4	2.45	11.3	Low
(b)	18,000	2	13	12	20	43	4	6	4.29	14.8	634
(c)	16,000	0	0	0	11	55	36	8	4.42	14.0	Good
11 (a)	197,000	5	50	23	26	11	0	2	3.50	8.7	Good
(b)	63,050	4	13	13	15	23	8	11	5.40	12.2	510
(c)	119,000	9	27	13	15	15	7	14	4.96	12.5	Good
13 (a)	30,000	2	10	12	45	12	12	7	4.0	11.6	50
(b)	8,600	0	2	0	15	62	9	12	4.1	12.6	185
(c)	6,200	22	6	7	15	30	20	0	2.3	5.8	60
15 (a)	170,000	13	27	17	18	13	7	5	4.40	13.1	Very low
(b)	23,000	10	25	17	13	15	5	15	3.20	10.0	26
(c)	153,000	17	39	12	10	6	2	0	2.5	9.3	16

in size, and subjective symptoms were minimal. Symptoms recurred rapidly, and when radiosodium therapy was unavoidably interrupted, roentgen therapy was resumed. Again he complained of nausea, etc., and treatment with urethane was attempted. After an initial response, the symptoms again increased in severity and the patient died.

radiosodium therapy. A third patient (Case 11) appears to be more radioresistant. Although (at 231st day) he carried on normal activities without discomfort, the leukocyte count increases steadily between treatments. A fourth patient (Case 12) improved clinically and subjectively after a

month of intensive radiosodium therapy but the hematologic response was only moderate. He soon suffered a relapse and died 150 days after the Na^{24} therapy had been initiated. Further information re-

his physician because of fatigue and sense of fullness in left upper quadrant. The spleen was palpable 12 cm. below costal margin and 9 cm. across. The liver edge was palpable. The blood picture (Table II) was typical of chronic

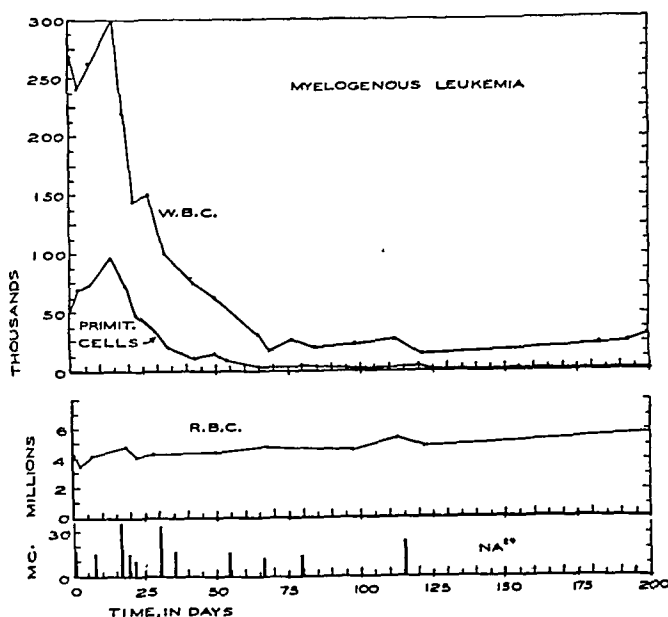


FIG. 3

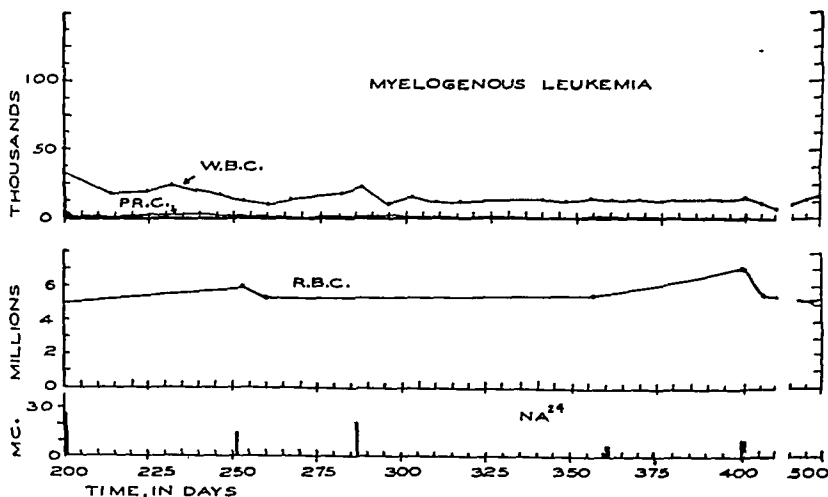


FIG. 4

FIGS. 3 and 4. Case 9. Chronic myelogenous leukemia. "Primitive cells" = leukocytes \times percentage of myelocytes and myeloblasts. The hemoglobin and platelet values have remained within normal limits. For further details see text and Table I.

garding these patients is included in Figures 3 and 4, Table II, and in the following brief case histories.

CASE 9. This patient is a male, aged fifty-one, and 86 kilograms in weight. He consulted

myelogenous leukemia. Fairly heavy initial treatment was required (see Fig. 3 and 4), but by the sixty-eighth day the liver was no longer felt and the spleen was barely palpable. After the first two months, all symptoms and the blood picture have been controlled by small and

infrequent doses. He has received 18 Na^{24} treatments (317 millicuries) over a period of 532 days.

CASE 10. This patient is a female, aged seventy-two, and 60 kilograms in weight. She was noted to have a high white count (see Table II) after a severe hemorrhage following a tooth extraction. The spleen measured 12 cm. below costal margin and 12 cm. across. She complained of generalized itching. With radiosodium therapy the erythrocyte count has improved, the platelet number has increased, the myelocytes and myeloblasts have been reduced, and the spleen now measures 8 cm. below costal margin and 8 cm. across. She has received four treatments (74 millicuries) over a period of sixty days.

CASE 11. This patient is a male, aged thirty-seven, weighing 76 kilograms. He was found to have abnormal cells in a routine blood smear taken for possible lead stippling (because of occupational hazards). A second blood examination showed typical leukemic changes. The spleen was 13 cm. below the costal margin and extended across the midline of the abdomen. The only complaint was that he tired easily. During an observational period of three months the leukocyte count and number of abnormal cells increased rapidly, and treatment with Na^{24} was started. He received moderate but frequent treatment over a period of six months. The leukocyte number decreased during this time. The erythrocyte counts and hemoglobin values improved. The spleen decreased slightly in size but was still palpable.

It is now (231st day) forty-nine days since the last dose of Na^{24} and he is in need of further therapy. He has received fourteen treatments (313 millicuries).

CASE 12. This patient was a male, aged eighty, and his weight was 78 kilograms. He complained of pruritus and weakness. The spleen was barely palpable. He continued to grow worse through three months of bed rest and frequent transfusions. At the beginning of radiosodium therapy, the leukocyte count was 118,000, with 35 per cent myelocytes and 11 per cent myeloblasts. The hemoglobin was 9 grams and the erythrocyte count was 3,100,000. Intensive therapy was given for one month (four treatments totalling 74 millicuries). At the end of this time the leukocyte count was 86,000 with 14 per cent myelocytes and no myeloblasts. He felt improved and left the hospital for busi-

ness reasons. Upon recurrence of symptoms he was given roentgen therapy over the spleen (1,000 r at 200 kv. during a period of one week) at another hospital. This was followed by severe nausea and lassitude but there was some improvement in the blood picture. Frequent transfusions were given but he became lethargic and died 150 days after radiosodium therapy had been initiated.

V. Subacute and Acute Myelogenous Leukemia. Although leukemia in children is notoriously resistant to any form of therapy at present, we have attempted treatment in a few cases. One of these (Case 13) was a young girl in whom the disease was myelogenous and apparently more chronic in nature than usual. She responded fairly well to Na^{24} therapy and within three months was allowed to leave the hospital for a brief period. She returned with pneumonia and showers of petechiae. The pneumonia cleared with sulfadiazine and, upon recurrence, with penicillin. Petechiae disappeared after radiosodium treatment. After about ten months, it became evident that the disease was progressing in spite of the improved leukocyte picture. The spleen continued to enlarge, she became anemic and it took longer for the platelets to increase after each treatment. A few small roentgen-ray doses were administered to the spleen but it continued to enlarge, she became weaker and died 347 days after beginning radiosodium therapy.

A second child with myeloid leukemia had a more acute condition (Case 14). A test dose of 4.5 millicuries was given but the patient showed no response and died three weeks later.

CASE 13. This patient was a female, aged six, weighing 15 kilograms. See Table II for hematologic data. She had several attacks of pneumonia and lassitude for several months. The spleen, liver, and lymph nodes were enlarged. She received twenty-six treatments (109 millicuries) over a period of 341 days. Autopsy showed lobar pneumonia and many leukemic cells in the enlarged spleen, lymph nodes, liver, bone marrow and epicardium.

CASE 14. The patient was a female, aged ten, weighing 29 kilograms. She had a history

of bruising easily, of anorexia and pallor for two months. For three weeks she had suffered nausea, vomiting, shortness of breath, pain in left side, and dizziness. There were moderately large tonsillar and epitrochlear nodes and the liver and spleen were palpable 9 cm. below the costal margin. Petechiae and ecchymoses were present on the legs and to a lesser extent over the entire body. She was anemic and the leukocyte count was 48,000 with 56 per cent myeloid

count increased to 120,000 and he became very weak. Roentgen therapy of the spleen was given in addition to the Na^{24} but these and frequent transfusions failed to stop the progression of the disease and he died 78 days after beginning the radiosodium therapy.

CASE 15. The patient was a male, aged forty-five, weighing 80 kilograms. He had a

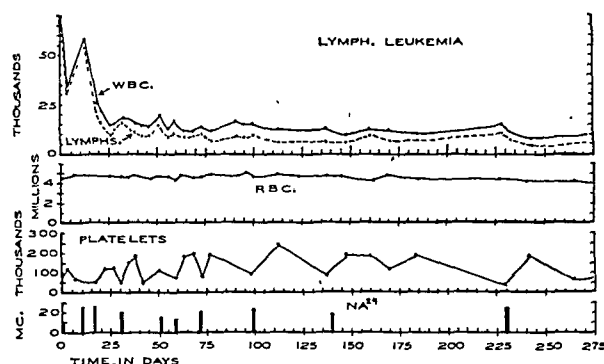


FIG. 5

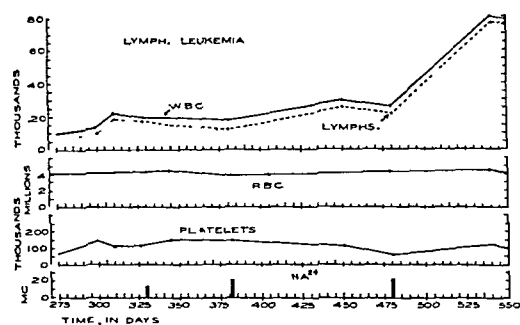


FIG. 6

cells, 40 per cent of which were myeloblasts. Only one dose of radioactive sodium (4.5 millicuries) was given and it was ineffectual. Autopsy showed widespread leukemic infiltration and disseminated hemorrhages. The spleen was very large and contained many infarcts as well as islands of erythropoiesis.

The third patient with the more acute form of the disease was an adult (Case 15). The initial response to radiosodium therapy was favorable in that by the thirty-third day the leukocyte count had dropped from 170,000 to 23,000 and he was subjectively improved. The spleen decreased slightly in size. Within a week the leukocyte

Figs. 5, 6, and 7. Case 17. Chronic lymphatic leukemia. "Lymphs" = leukocytes \times percentage of lymphocytes. Note that platelet count was low at beginning of therapy, and, during first year, each treatment was followed by an immediate increase in number. "T" on "RBC" curve indicates transfusion. For further details see text.

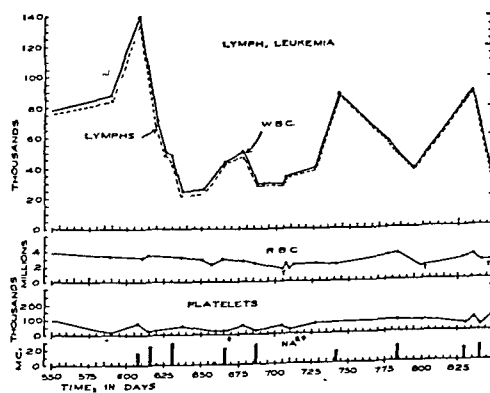


FIG. 7

sudden onset of weakness and sense of fullness in the abdomen. A bone marrow biopsy showed replacement of erythropoietic cells by myeloblasts. The spleen was greatly enlarged. Five treatments were given (105 millicuries) over a period of sixty-two days. See Table 11 for the hematologic data.

Another patient (Case 16) with rapid progression of the disease was treated with four small doses of Na^{24} (a week apart), but failed to show any improvement. She died forty days after beginning therapy.

CASE 16. The patient was a female, aged forty-nine, weighing 60 kilograms. She had re-

ceived extensive roentgen treatment to the abdomen ten years previously for metastases from a sarcoma of the uterus. She entered the hospital because of generalized malaise, anorexia, night sweats and nausea, and daily fever of $100-103^{\circ}\text{F}$. increasing for six weeks. She then developed discoloration, swelling and recurring edema of both breasts and about both eyes. A biopsy of a breast showed infiltration with leukemic cells. Blood examination showed leukocyte count, 6,650, with 9 per cent myeloblasts; 2,900,000 erythrocytes; 9 grams hemoglobin. Platelets were very low. She was given four small weekly doses of Na^{24} and local roent-

The second patient (Case 18) has been controlled with even less frequent radiosodium treatments than the previous case. His physical condition improved rapidly and at present (550 days after first treatment) he still continues his normal activities. Further details are given in Figure 8 and in the case outline below.

CASE 17. This patient is a male, aged sixty-two, weighing 80 kilograms. At admission he complained of weakness and frequent nose-bleed. He had generalized lymphadenopathy; the liver and spleen were not palpable. Biopsy

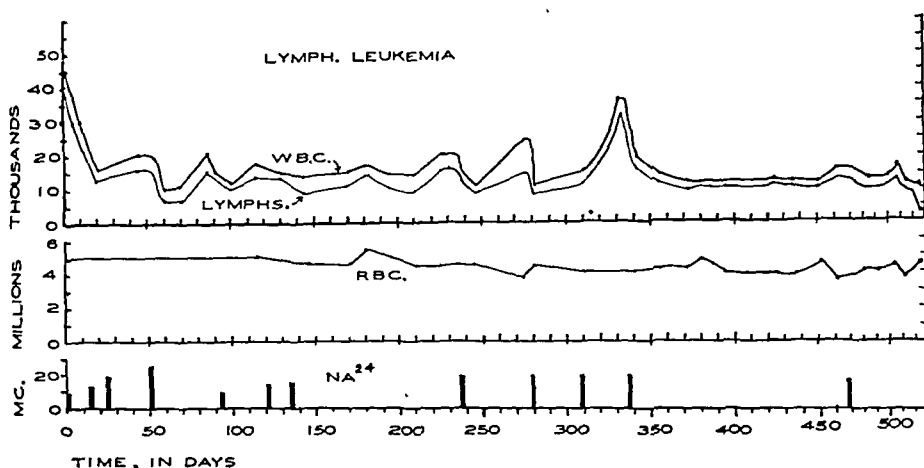


FIG. 8. Case 18. Chronic lymphatic leukemia. "Lymphs" = leukocytes \times percentage lymphocytes. See text for details.

gen radiation to the breast lesions. She failed to show any subjective improvement and soon died.

VI. Chronic Lymphatic Leukemia.

(a) Patients with no Previous Radiation Therapy. Only 2 such patients have been treated with radiosodium but both have responded very well. One of these (Case 17) was controlled very easily for over two years. During this time he was free of symptoms and was able to participate in all of his usual activities. At the present time (933 days) he tires easily, and requires frequent transfusions. Although he still improves after each radiosodium treatment, his spleen and lymph nodes are gradually but steadily enlarging. Further details are indicated in Figures 5, 6, and 7, and in the summary of the case history below.

of cervical lymph node showed lymphatic leukemia. His blood count was: 78,450 leukocytes per c.mm.; 91 per cent lymphocytes; 8 per cent neutrophils; 1 per cent eosinophils; 4,380,000 erythrocytes per c.mm.; 12.6 grams hemoglobin per 100 cc.; and the platelets were very low. Within two days of the first small dose of radiosodium, he felt better and the blood picture had improved. Twenty-six days after beginning Na^{24} therapy he resumed his usual activities. The nodes were smaller and the blood count was: 14,000 leukocytes; 68 per cent lymphocytes; 30 per cent neutrophils; 2 per cent monocytes; 4,700,000 erythrocytes; 13.3 grams hemoglobin and 120,000 platelets. During the first 200 days of treatment the platelets were definitely increased after each dose. Later, about 700 days after beginning therapy, treatment was unavoidably interrupted and by the time it was resumed he was again weak, was anemic and had some ecchymosis. Monthly treatments

have reduced the leukocyte count, have checked the bleeding tendency and he feels better. Frequent blood transfusions are still required, the spleen and lymph nodes are slowly but steadily enlarging. Hospitalization has not been required. He has received twenty-four treatments (total of 468 millicuries) over a period of 920 days.

CASE 18. This patient is a male, aged sixty-three, weighing 85 kilograms. He consulted his physician because of abdominal and joint pains. He had an enlarged spleen and generalized lymphadenopathy. The blood count was: 45,000 leukocytes; 83 per cent lymphocytes; 10 per cent neutrophils; 5,000,000 erythrocytes; 14.8 grams of hemoglobin and 150,000 platelets. Sixty days after the first radiosodium treatment, the blood count was: 9,000 leukocytes; 78 per cent lymphocytes; 20 per cent neutrophils; and 2 per cent monocytes. The spleen and lymph nodes have not been palpable since this time (i.e., sixty days). His physical condition improved rapidly and remains excellent. The latest blood count (532 days) shows: 12,300 leukocytes; 18 per cent lymphocytes; 81 per cent neutrophils; 1 per cent monocytes; 4,500,000 erythrocytes; 13.6 grams of hemoglobin. He has received twelve treatments (207 millicuries) over a period of 525 days.

(b) Patients Who Had Received Previous Radiation Therapy. Two patients, terminal and no longer benefited by roentgen therapy, were given several doses of radiosodium but the progression of the disease was not stopped.

CASE 19. This patient was a female, aged forty-five, weighing 55 kilograms. The condition had been diagnosed three years previously because of an enlarged spleen. Weakness developed a year and a half later at which time roentgen treatments were begun. She responded to small doses of roentgen therapy but the liver and spleen again increased in size, and she became anemic. The blood count, when Na²⁴ therapy was begun, showed: 115,000 leukocytes; 1,000,000 erythrocytes and 3.8 grams of hemoglobin. A dose of 17 millicuries was given at this time, and a month later one of 10 millicuries was administered. Two weeks later the erythrocyte count was 2,200,000, the hemoglobin was 5.8 grams, and the leukocyte count

was 95,500. The anemia then grew worse, the leukocyte count increased, and the patient died two months after treatment with radiosodium was begun.

CASE 20. This patient was a female, aged forty-one, weighing 58 kilograms. She was first seen because of increasing fatigability. Her spleen and liver were enlarged. The diagnosis was made by sternal marrow biopsy. She received roentgen treatment for about nine months. At the time Na²⁴ therapy was started, the leukocyte count was 6,500, the erythrocyte count was 3,000,000, and the hemoglobin was 7.4 grams. She was given 11.8 millicuries at this time. When the second (and last) treatment of 15 millicuries was given thirty-nine days later, the leukocyte count was 3,800, the erythrocyte count was 1,640,000, and the hemoglobin was 6.4 grams. The anemia increased, the number of platelets continued to decrease, and bleeding tendencies developed which failed to respond to frequent transfusions. She died 109 days after the Na²⁴ treatment had begun.

VII. Acute Lymphatic Leukemia. Radiosodium therapy has been attempted with two children having no previous treatment. In both cases, it was unsuccessful except for temporary improvement in physical condition and relief of pain.

CASE 21. This patient was a male, aged nine, weighing 20 kilograms. He had migratory pain and occasional elevation of temperature for three months previous to admission. The cervical, axillary and right epitrochlear nodes were slightly enlarged. The liver and spleen were not enlarged and there were no petechiae. A smear of the sternal bone marrow indicated acute leukemia. The blood count at beginning of therapy was as follows: 3,750 leukocytes, 11 per cent lymphoblasts, 58 per cent lymphocytes, 31 per cent neutrophils, 3,800,000 erythrocytes and 12.3 grams of hemoglobin. He was given five treatments (of 3 millicuries each) during the first month. After the first week or two of treatment he felt better, and by the end of the month he was much stronger, was free of pain, and was able to walk about. A bone marrow study at this time indicated presence of the disease, and treatments were continued. The spleen, liver and lymph nodes increased in size, and he eventually became anemic. Three months after beginning therapy, the platelets dropped alarmingly low, he became bed-ridden,

and pain returned. He died about a hundred days after therapy had begun. He had received eleven treatments (total of 49 millicuries). Terminally, the main leukemic changes appeared in the bone marrow, and the only other infiltrations found were in the testes and epididymides.

CASE 22. This patient was a female, aged three and a half, weighing 15 kilograms. She did not appear critically ill but had generalized lymphadenopathy. The liver and spleen were palpable 9 cm. below the costal margin. Three days later, petechiae were noted on the face and she was bleeding from the gums. Liver and spleen were measurably larger. Only one treatment of 4.5 millicuries of radiosodium was given

ment. She died twenty-four days after the radiosodium administration.

VIII. Other Generalized Neoplastic Conditions.

(a) Polycythemia vera. Only one case has been treated and this has responded very well. The manner of treatment and the change in the blood picture are shown in Figure 9.

CASE 23. This patient is a male, aged sixty-nine, weighing 65 kilograms. His chief complaint was dizziness, bleeding of the gums, and headaches. The blood count showed: 24.7 grams of hemoglobin, 7,420,000 erythrocytes, 8,150 leukocytes, 90 per cent neutrophils, 2 per cent

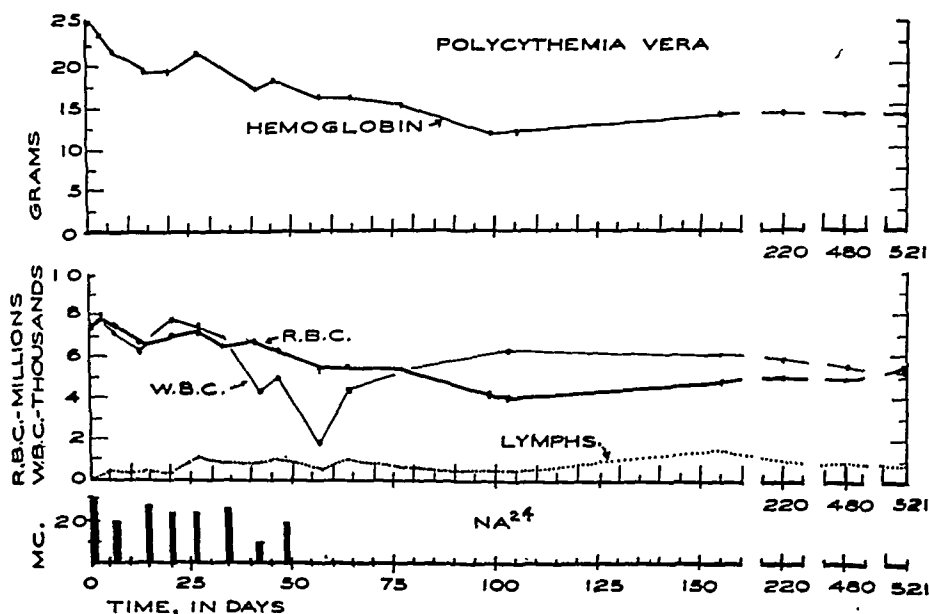


FIG. 9. Case 23. Polycythemia vera. "Lymphs" = leukocytes \times percentage lymphocytes. See text for details.

as there was an unavoidable interruption in the supply and she died before more could be obtained. At the time of radiosodium administration, the leukocyte count was 171,000, the percentage of lymphoblasts was 76, and the erythrocyte count was only 2.36 million. During the few days following treatment there was a slight decrease in the leukocyte count and a slight rise in the number of erythrocytes. The platelet count and general condition grew worse. A week after the treatment the erythrocyte count became very low. The petechiae became more generalized; the liver and spleen remained about the same as at the time of treat-

ment. She died twenty-four days after the radiosodium administration. The blood count is within normal limits, i.e., 13.9

grams hemoglobin, 5,370,000 erythrocytes, 5,200 leukocytes, 83 per cent neutrophils, 1 per cent monocytes, 1 per cent basophiles, and 15 per cent lymphocytes. He received eight treatments (total of 185 millicuries) given over a period of forty-eight days.

(b) Sympatheticoblastoma. A patient with generalized bone metastases secondary to sympatheticoblastoma of unknown origin has been treated with radiosodium and the results have been promptly beneficial though temporary.

CASE 24. This patient is a male, aged twenty-one, weighing 80 kilograms. At admission, he had a hard, fixed, 10 by 8 cm. mass on lateral chest wall of one and one-half years' duration. Pain in region of mass was present for one month previous to admission. Surgical removal showed the neoplasm to be invading the fifth rib. Postoperative roentgen treatment was given to the chest wall. Six months later he returned with generalized metastases and diplopia associated with destruction of the sphenoid bone. The diplopia and pain accompanying the metastases cleared with small doses of roentgen radiation. Because of the widespread nature of the metastases and their relatively great radiosensitivity, he was started on radiosodium therapy at the next recurrence. After four doses (total of 65.9 millicuries) given in a ten day period, all pain disappeared. An additional dose of 16.6 millicuries was administered a week later and he then remained free of pain for four months. Since then, moderate doses (15-25 millicuries) have been administered at about monthly intervals. His physical improvement has been remarkable and pain has been completely relieved within two to three days following each treatment. He is able to carry on normal activity within limits. Twice, the treatments have been severe enough to produce a slight lymphopenia and leukopenia, but these disappeared within a few days. The erythrocyte count, hemoglobin concentration and platelet number have never been low. He has received nine treatments over a period of 150 days for a total of 180 millicuries. He is now in need of further treatment as diplopia has returned and metastases have appeared in the frontal region of the cranium.

DISCUSSION

It is too early, and the data are too few,

to permit a final evaluation of the radiosodium therapy. It does appear that it is an effective means of giving protracted whole body irradiation. In a few individuals, the radiation has produced good results, and the method appears to be adaptable to chronic myelogenous leukemia, chronic lymphatic leukemia, polycythemia vera, and to other radiosensitive generalized diseases. The response to radiosodium therapy is not good when (1) the disease is acute, (2) the radioresistance of the abnormal cells is high, and (3) the hemopoietic system is already damaged.

It may be that at least some of the effect of radiophosphorus is not due to differential concentration of the P^{32} alone, as its general reaction in leukemias, etc., can be duplicated by radiosodium whose radiation is definitely widespread throughout the body.

The rapidity and degree of response, as well as the duration of the regression, can usually be regulated by the amount of each radiosodium dose and the frequency of treatment.

Radiation sickness sometimes occurs in patients treated with roentgen rays over large areas, with intensive doses, or in especially sensitive individuals. It has been possible to obtain very satisfactory responses in every individual treated with radiosodium without producing radiation sickness. Some slight nausea for a few days followed heavy and frequent treatment in 2 patients. Likewise, the protraction of the irradiation may account for absence of radiation sickness in radiophosphorus therapy.

There seems to be no complication nor lack of response due to giving the radiosodium by mouth. This method of administration avoids some of the complications and limitations of intravenous injection as used by some in radiophosphorus therapy and by Thygesen *et al.*¹⁷ in radiosodium treatments.

The use of radiosodium will probably not become widespread as it is limited to laboratories near the source of supply (its half-life is only about fifteen hours). The investigation is being continued in the hope of

learning more about its effectiveness not only in treatment of chronic leukemia, etc., but possibly in other forms of neoplasia which might be too widespread for proper treatment with roentgen radiation, and which might need a shorter, more intense period of irradiation than one could afford to give with radiophosphorus because of its longer half-life (fourteen days).

CONCLUSIONS

The limited data permit only tentative conclusions. Radiosodium, taken by mouth, in a suitable quantity and at appropriate intervals, is effective in reducing symptoms of chronic myelogenous leukemia, chronic lymphatic leukemia and polycythemia vera. The rate of response to each treatment appears to be intermediate between that of roentgen therapy and treatment with radiophosphorus. The contraindications are similar to those for other forms of radiation therapy.

The writers wish to express their appreciation to Dr. G. Failla for his encouragement and helpful criticisms throughout the course of this study.

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REFERENCES

1. ERF, L. A. Retention of radiophosphorus in whole and aliquot portions of tissues of a patient dead of leukemia. *Proc. Soc. Exper. Biol. & Med.*, 1941, 47, 287-289.
2. EVANS, T. C., and QUIMBY, E. H. Studies on effects of radioactive sodium and of roentgen rays on normal and leukemic mice. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1946, 55, 55-66.
3. GELLHORN, A., MERRELL, M., and RANKIN, R. M. Rate of transcapillary exchange of sodium in normal and shocked dogs. *Am. J. Physiol.*, 1944, 142, 407-427.
4. HAMILTON, J. G. Rates of absorption of radio-sodium in normal human subjects. *Proc. Nat. Acad. Sc.*, 1937, 23, 521-527.
5. HAMILTON, J. G. Use of radioactive tracers in biology and medicine. *Radiology*, 1942, 39, 541-572.
6. HAMILTON, J. G., and STONE, R. S. Intravenous and intraduodenal administration of radioactive sodium. *Radiology*, 1937, 28, 178-188.
7. HAMILTON, J. G., and STONE, R. S. Excretion of radio-sodium following intravenous administration in man. *Proc. Soc. Exper. Biol. & Med.*, 1937, 35, 595-598.
8. HEMPELMANN, L. A., REINHARD, E. H., MOORE, C. V., BIERBAUM, O. S., and MOORE, S. Hematologic complications of therapy with radioactive phosphorus. *J. Lab. & Clin. Med.*, 1944, 29, 1020-1041.
9. KENNY, J. M. Radioactive phosphorus as a therapeutic agent in malignant neoplastic disease. *Cancer Research*, 1942, 2, 130-145.
10. KENNY, J. M., and CRAVER, L. F. Further experiences in treatment of lymphosarcoma with radioactive phosphorus. *Radiology*, 1942, 39, 598-607.
11. KENNY, J. M., MARINELLI, L. D., and WOODARD, H. Q. Tracer studies with radioactive phosphorus in malignant neoplastic disease. *Radiology*, 1941, 37, 683-687.
12. LAWRENCE, J. H., SCOTT, K. G., and TUTTLE, L. W. Studies on leukemia with the aid of radioactive phosphorus. *Internat. Clin.*, 1939, 3, 33-58.
13. LOW-BEER, B. V. A., LAWRENCE, J. H., and STONE, R. S. Therapeutic use of artificially produced radioactive substances. *Radiology*, 1942, 39, 573-597.
14. MARINELLI, L. D. Dosage determinations with radioactive isotopes. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 210-216.
15. MARINELLI, L. D., QUIMBY, E. H., and HINE, G. J. Dosage determination with radioactive isotopes. II. Practical considerations in therapy and protection. *AM. J. ROENTGENOL. & RAD. THERAPY*, Feb., 1948, 59, 260-281.
16. REINHARD, E. H., MOORE, C. V., BIERBAUM, O. S., and MOORE, S. Radioactive phosphorus as a therapeutic agent. A review of the literature and analysis of results of treatment of 155 patients with various blood dyscrasias, lymphomas, and other malignant neoplastic diseases. *J. Lab. & Clin. Med.*, 1946, 31, 107-215.
17. THYGESEN, J. C., VIDEBOEK, A., and VILLAUME, I. Treatment of leukemia with artificial radioactive sodium. *Acta radiol.*, 1944, 25, 305-316.
18. TUTTLE, L. W., ERF, L. A., and LAWRENCE, J. H. Studies on neoplasms with aid of radioactive phosphorus; phosphorus metabolism of nucleoprotein, phospholipid and acid soluble fractions of normal and leukemic mice. *J. Clin. Investigation*, 1941, 20, 57-61.

EXPERIMENTAL STUDIES ON THE MOTILITY OF THE GASTRIC MUCOSA IN DOGS

A PRELIMINARY REPORT*

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THE physiologic movements of the gastric mucosa has long been of interest to radiologists. Although the concept that the gastric mucosa was capable of motion independently of the main muscular coat has been widely accepted,^{2,3,4} there has been no definite proof of this phenomenon in the living subject. We set out, therefore, to study the movements of the muscularis mucosae and the muscularis propria in the living dog by means of roentgenoscopic and roentgenographic studies.

ANATOMY

The gastric wall in the dog, like that of the human, consists of four coats or layers. The outermost coat is the serosa which consists of a thin layer of connective tissue covered with peritoneum. Beneath the serosa is the muscularis propria which is composed of an outer longitudinal, a middle circular, and an inner oblique layer of smooth muscle. The submucosa lies beneath the muscularis propria and is made up of a strong but loose layer of connective tissue closely attached to the innermost coat or mucosa. The latter consists of a lining of columnar epithelium, the gastric glands, and the muscularis mucosae. This muscle layer is composed of an external layer of longitudinal smooth muscle and an internal layer of circular smooth muscle.

The muscularis mucosae participates in the structure of the mucosal folds and follows the contour of the gastric mucous membrane while the muscularis propria does not. The submucosa contains a rich supply of blood vessels and nerves. The

latter are composed of branches of the vagus or parasympathetic nerves and branches from the celiac axis derived from the sympathetic nervous system. The vagal branches to the anterior wall of the stomach are derived largely from the left vagus nerve. The nerves connect with two plexuses: the myenteric plexus of Auerbach which lies between the longitudinal and circular layers of the muscularis propria, and the submucous plexus of Meissner which lies in the submucosa.

The gross anatomy of the stomach need not be considered further for our purposes except to say that we observed mucosal movements best in the pars media and the prepyloric region. The roentgenoscopic and roentgenographic studies of the dog's stomach both with barium and with the method to be described were made in the straight prone position.

PHYSIOLOGY

Radiologists have contributed much to the knowledge of the physiology of the gastric mucosa. Forssell^{3,4} called attention to the importance of the motion of the mucous membrane in the finer regulation of the passage of food through the intestinal tract and its role in facilitating digestion. He presented formalin-fixed specimens of human and animal stomachs to show the formation of digestive chambers by the mucosa, adapted to the size and contour of individual food particles. He demonstrated changing mucosal patterns in the stomach by serial roentgenograms. He was able to show examples of prominent mucosal re-

* The authors wish to acknowledge the valuable suggestions and help of Drs. Robert C. Horn, Jr., Robert P. Barden, Philip J. Hodes, Arthur Pryde, Julius Comroe and I. S. Ravdin in the preparation of this paper. Miss Gloria Brazill and Mr. Norman McArthur rendered technical assistance. The work was done in the Harrison Department of Surgical Research, School of Medicine, University of Pennsylvania and the Department of Radiology in the Hospital of the University of Pennsylvania.

lief in the presence of a smooth outer wall and low, almost obliterated mucosal folds in the presence of contraction of the muscularis propria. These findings, he thought, indicated that the formation and motion of the mucosal folds was a function of the muscularis mucosae independently of the muscularis propria, although the latter influenced the general mucosal relief, depending on its degree of contraction. He believed that the folds of the gastric mu-

when the muscularis propria of the stomach contracts the lumen of the stomach along the greater curvature and that even though the folds of mucosa contain the firmly attached muscularis mucosae, it cannot be regarded as proof that the muscularis mucosae causes the rugae to form or move after they are formed. They regarded the mucosal folds of the stomach as persistently recurrent and constant for a given patient. They found that the plica

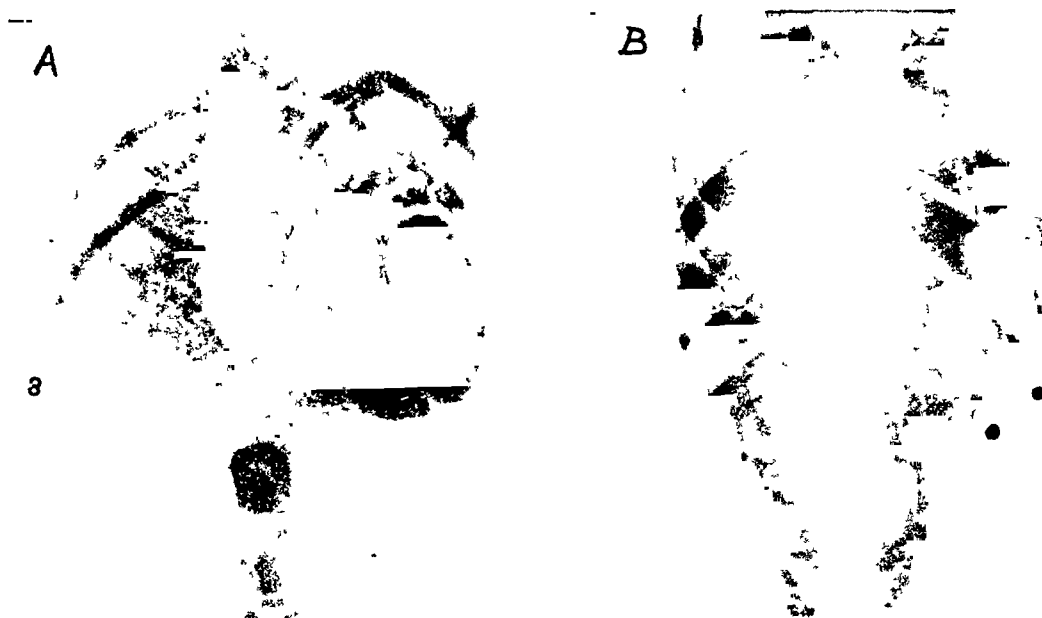


FIG. 1. *A*, survey roentgenogram of dog No. 222 immediately following the injection of 25 cc. of thorotrast into the submucosa of the stomach. Wire sutures along each curvature were difficult to see. *B*, survey roentgenogram of dog No. 607, twenty-four hours after the injection of 12 cc. of thorotrast into the submucosa of the stomach. The lead shot have been sutured along the greater and lesser curvatures of the stomach. They can be identified much better.

cosa were transient structures formed by contraction of the muscularis mucosae and that the contraction-form of the mucous membrane tended to be typical for each part of the gastrointestinal tract.

The Cole Collaborators² made an exhaustive study of the mucous membrane of the gastrointestinal tract. They made serial roentgenograms of a large number of patients and also concluded that the gastric peristalsis is a function of the muscularis mucosae and independent of the muscularis propria. They believe that large folds of mucous membrane must be formed

angularis was the only "permanent" fold in the stomach in the sense that it could not be obliterated by distention. They concluded that progressive gastric peristalsis was a function of the muscularis mucosae.

Golden^{6,7} made serial roentgenograms at two second intervals of a dog's stomach in which lead shot had been imbedded in the serosa along each curvature. By means of a barium meal he was able to show thinning of the stomach wall under a peristaltic wave. This could be explained, according to Golden, by thinning of the mucosa and submucosa. He also showed the mucosal

folds in the antrum which ran irregularly transversely to the long axis of the stomach became nearly parallel to it during antral systole. This was accomplished by a cephalad motion of the mucous membrane.

Gianturco⁵ studied gastric motility in cats by placing lead shot along each curvature just under the serosa and then giving

disorders of the gastrointestinal tract.⁷ The importance of the autonomic nervous system in the control of gastric motility is well recognized although all known types of gastrointestinal motility have been observed following section of the extrinsic nerves.⁸ Certain types of motility, especially rhythmic contractions, are primarily

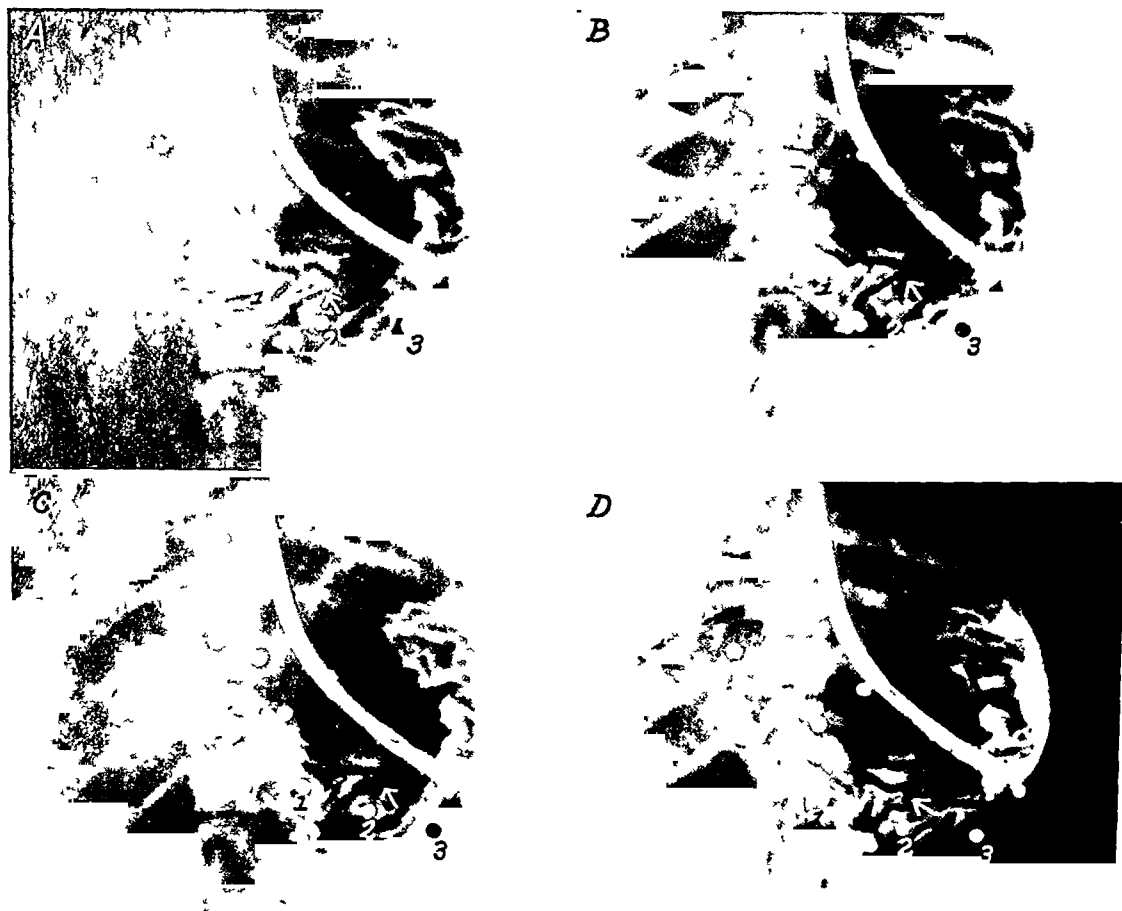


FIG. 2, A, B, C, D. The same dog as Figure 1A, four months later, illustrating excellent distribution of the thorotrast. These roentgenograms of dog No. 222 were made at two minute intervals after the administration of 50 cc. of a barium suspension, 50 cc. of water and 150 cc. of air through a Miller-Abbott tube in the stomach. At the arrows, note the definite changes in mucosal pattern without change in the position of the lead shot.

them a barium meal. He found that motion of the gastric wall could be detected on only 7 of 100 roentgenograms made at one second intervals in cats which had fasted for two days. Only shallow peristaltic contractions were demonstrated.

Recent studies have emphasized the importance of the neuromuscular junction in

myogenic in origin. In general, vagus stimulation augments gastric motility and splanchnic stimulation inhibits it, but the reverse may occur and Kuntz⁸ feels that the initial tonic state of the gastric musculature is the most important factor in determining the response to such stimulation.

Alvarez¹ states that stimulation of the

vagus nerves had little if any effect on the muscularis mucosae. Strong stimulation of the splanchnic nerves usually produced relaxation.

He described small pendular movements and larger tonus waves due to contraction of the muscularis mucosae of the stomach. Golden⁷ considered the myenteric plexus of Auerbach as vagal in origin and the submucosal plexus of Meissner as splanchnic or sympathetic. Alvarez¹ considered prevention of spasmodic contraction one of the main functions of the myenteric plexuses.

Steggerda and Gianturco¹⁰ injected thorotrast under the serosa of the colon in cats in order to study motility and after seven months obtained a uniform distribution of the thorotrast completely encircling the colon.

This work suggested to us a method for distinguishing between the muscularis propria and the muscularis mucosae in the living animal during roentgenographic and roentgenoscopic examination. We first employed wire sutures through the serosa, but these proved difficult to identify and we changed to lead shot (Fig. 1). The shot served to detect motion of the gastric wall due to contraction of the muscularis propria. In order to identify the mucosa we planned to inject a contrast medium into the submucosa.

A laparotomy was performed on a healthy dog (No. 222) weighing 6.4 kg., under intravenous sodium pentobarbital anesthesia. Seven cubic centimeters of colloidal thorium dioxide (thorotrast) were injected into the submucosa of the anterior wall of the stomach about 10 cm. from the pylorus, 6 cc. about 6 cm. from the pylorus near the greater curvature, 10 cc. about 3 cm. from the pylorus near the greater curvature, and about 2 cc. in the anterior wall of the first portion of the duodenum. Six wire sutures were placed along each curvature at 1 cm. intervals extending to the first portion of the duodenum (Fig. 1A). Subsequent roentgenograms over a period of several months showed a progressive spread of the thorotrast throughout the submucosa.

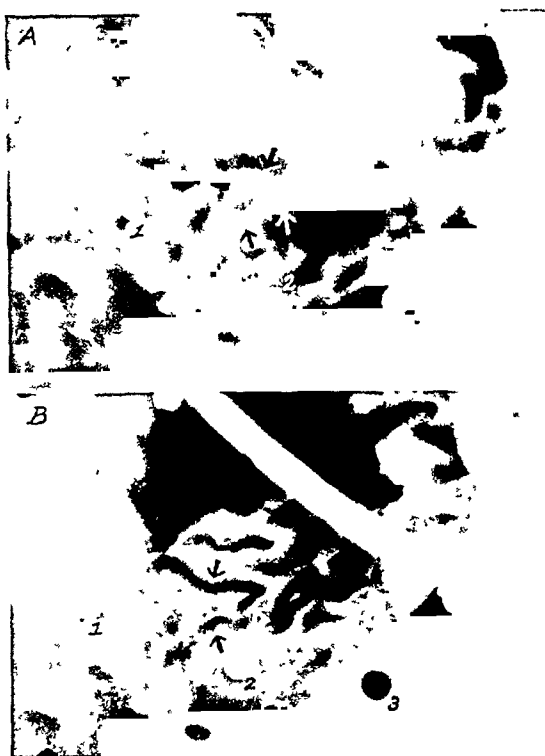


FIG. 3. The same dog as Figure 1 A four months later. Compare the position of lead shot 1, 2, and 3. They seem to be in the same position and on that observation it was regarded as against any movement of the muscularis propria. The mucosal pattern (at arrows) has changed. A and B are enlarged views of portions of Figure 2 (B and D respectively).

As stated previously, the wire sutures proved difficult to visualize and four months later another laparotomy was performed and six lead shot were sutured through the serosa to the greater curvature at 3 cm. intervals and three to the lesser curvature extending to the first portion of the duodenum. At this time roentgenographic studies showed that the thorotrast had spread out through the stomach wall producing a very satisfactory visualization of the mucosal folds of the stomach. At operation the gastric wall was only slightly indurated and there were no adhesions.

Various techniques were employed in studying this dog but the procedure which gave the best results was as follows: The dog was placed on a roentgenoscopic table after a twelve hour fast and secured with rawhide straps in a prone position. A modi-

fied Miller-Abbott tube was passed into the stomach and the balloon inflated with about 30 cc. of air. The tube was then pulled out as far as possible in order to block off the cardiac opening of the stomach. Fifty cubic centimeters of water

With such a technique, we were able to demonstrate definite changes in the form of given mucosal folds during a period in which the position of the shot remained relatively constant (Fig. 2 and 3). This was interpreted as evidence that the mucosa

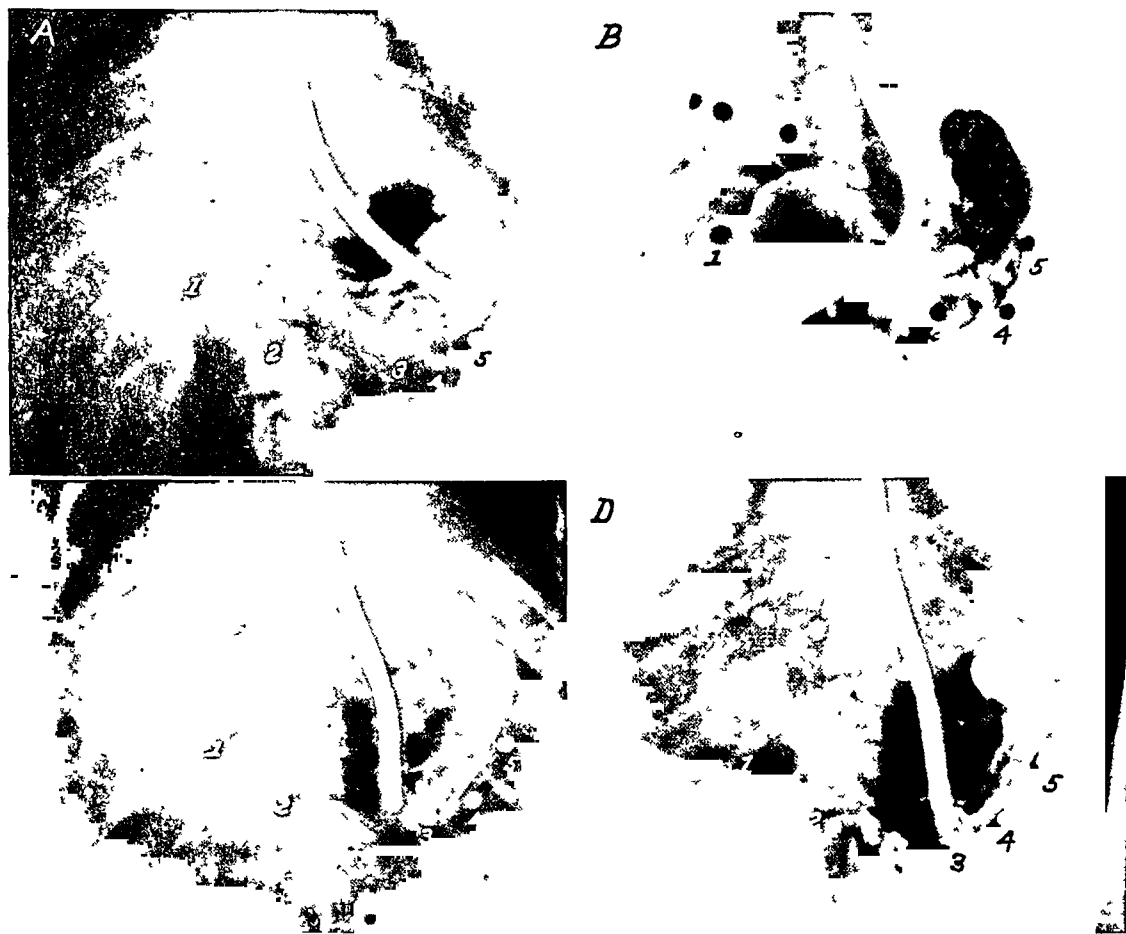


FIG. 4. *A, B, C, D.* Roentgenograms of dog No. 222 (Fig. 1*A*) twelve months after the experiment was begun. The thorotrast is still distributed throughout the submucosa. Ten minutes after the subcutaneous injection of 0.1 mg. of mecholyl in 1.0 cc. of physiological saline, 50 cc. of air and 30 cc. of water had been injected through the Miller-Abbott tube the films were exposed at intervals of one-half minute. Note the position of the lead shot in the various exposures. The shot along the greater curvature have been numbered from 1 to 5 in each exposure. In addition there are changes in the mucosal pattern.

were then injected through the tube, followed by 100 cc. of air and the tube was clamped. On some occasions we obtained good results with a mixture of 4 parts barium to 50 parts water. Roentgenograms were made at one-half or one minute intervals employing either spot films or the overhead tube with a tunnel beneath the dog to permit rapid changing of cassettes.

possesses the ability to move, due to contraction of the muscularis mucosae, independently of the muscularis propria.

We were unable to observe active peristalsis with such a technique and therefore we employed mecholyl (acetyl-beta-methylcholine), a parasympathicomimetic drug, to stimulate peristalsis. One-tenth of a milligram in 0.1 cc. of physiologic saline

solution given subcutaneously produced active peristalsis in a few minutes. As soon as the roentgenoscopic examination showed active motion of the shot, films were exposed at one-half or one minute intervals. By this method we were able to demon-

estimated that 70 to 80 per cent of the thorotrast was in the submucosa (Fig. 8 and 9). This reaction consisted of a large number of phagocytes which were filled with thorotrast granules. Areas of necrosis were present within the mass of phagocytes.

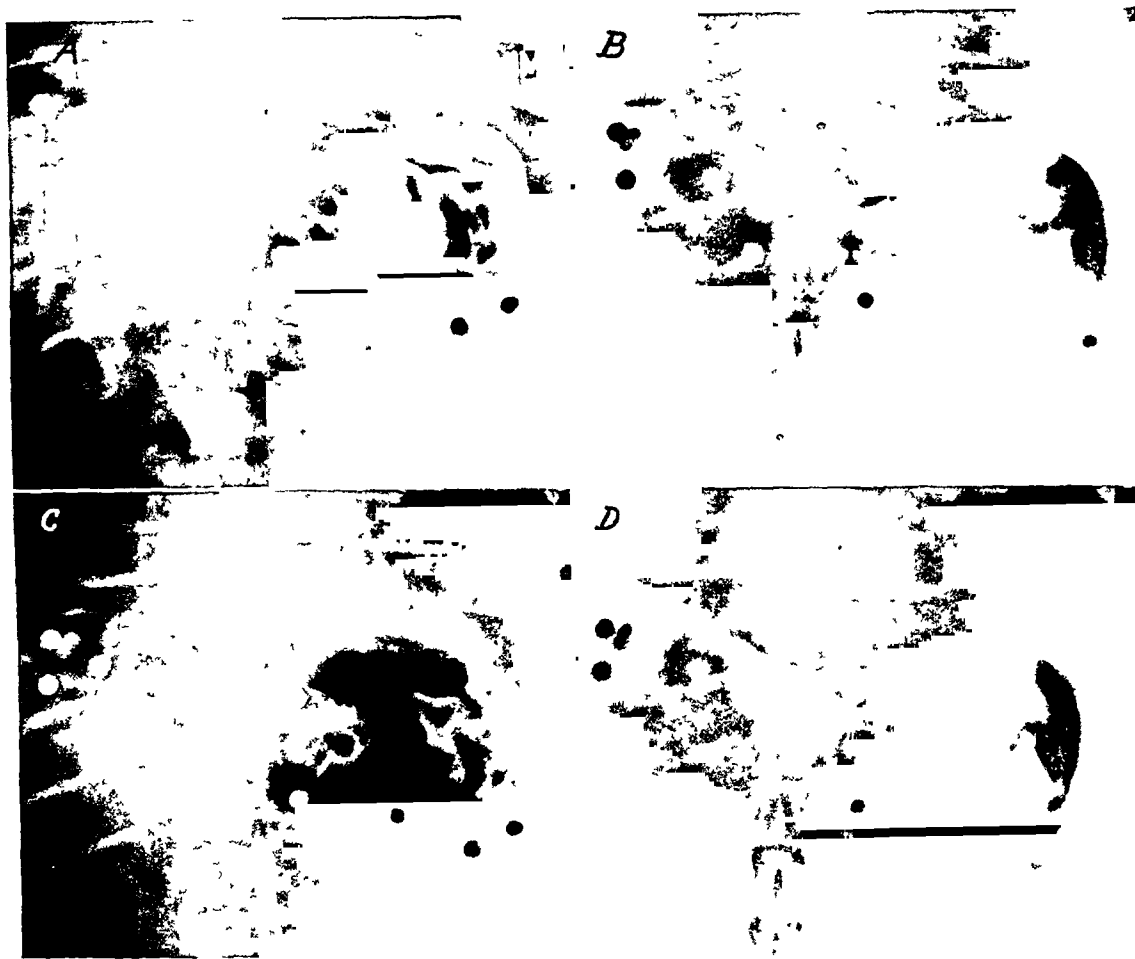


FIG. 5, A, B, C, D. The same dog as Figure 1B, nine months later. Roentgenograms of dog No. 607 made at one-half minute intervals following the injection of 50 cc. of air and 50 cc. of water through the Miller-Abbott tube. Note the change in the position of the shot and the changes in mucosal pattern.

strate changes in mucosal patterns at the same time that contraction of the muscularis propria was taking place (Fig. 4). This confirms, we believe, the observation that contraction of the muscularis propria does produce changes in mucosal patterns.

After thirteen months had elapsed, a biopsy including the full thickness of the gastric wall was obtained from the dog and our pathologist, Dr. Robert C. Horn, Jr.,

The slides bore a striking resemblance to the photomicrographs published by Mora⁹ of tissue removed from a granulomatous lesion of the breast thirteen months after the intramammary injection of thorotrast.

We have injected thorotrast into the submucosa of the anterior gastric wall of 5 other dogs and in 2 of them we have been able to confirm the observations made on the first dog (Fig. 5, 6 and 7). Three other dogs do not yet show an ideal distribution

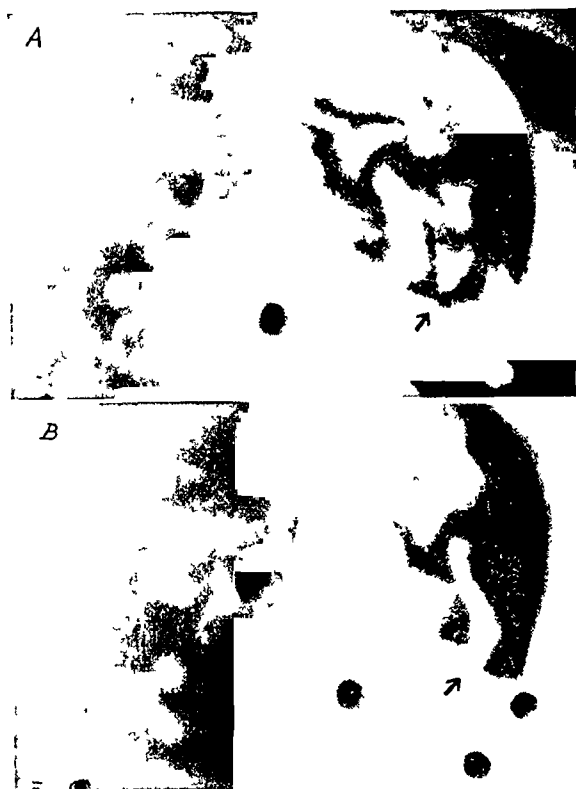
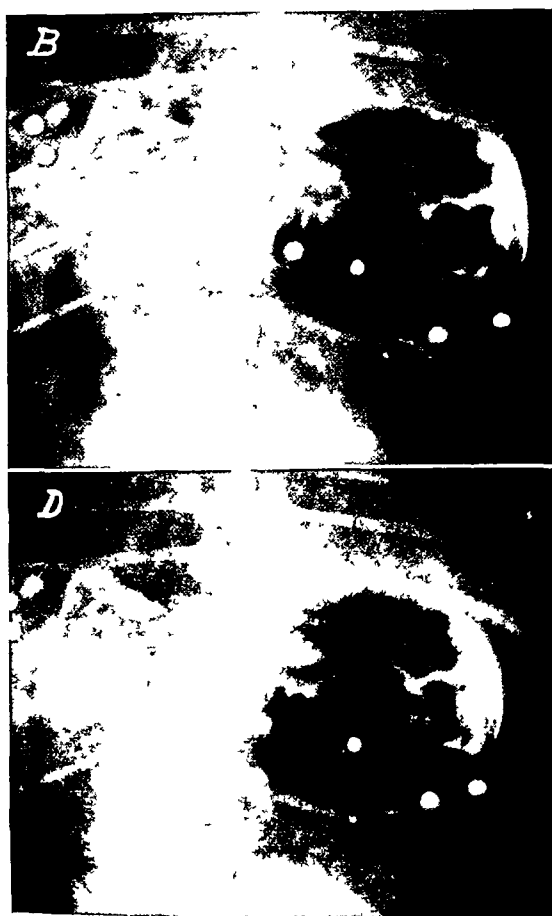
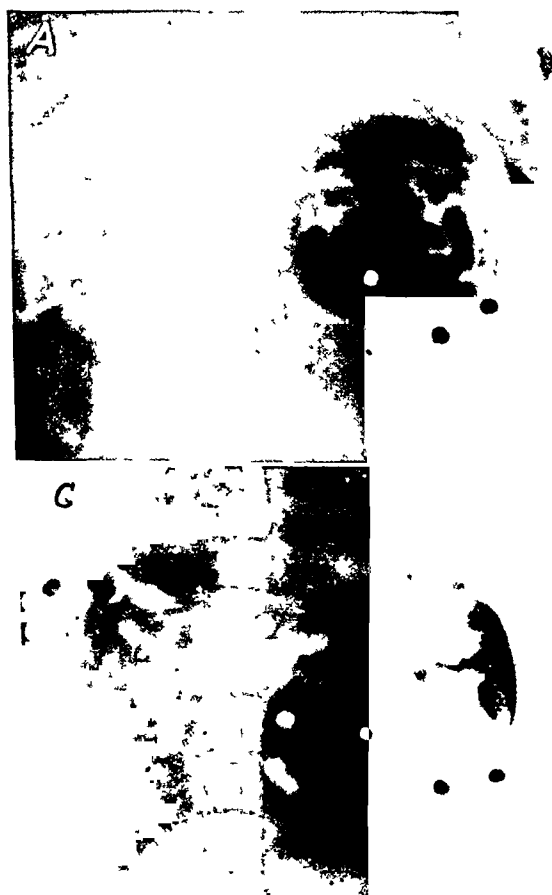


FIG. 6. *A* and *B*, enlarged views of portions of Figure 5 (*B* and *D* respectively). The changes in the mucosal pattern are seen best at the site of the arrow.

FIG. 7. *A, B, C, D*. Roentgenograms of dog No. 607 made shortly after those in Figure 5, and ten minutes after the subcutaneous injection of 0.1 mg. of mecholyl at one-half minute intervals. Note the marked change in the position of the lead shot and the changes in mucosal pattern.



of the thorotrast. Five or six months has been the usual time interval before such a distribution was obtained.

We also employed pantopaque as a contrast medium but we were unable to obtain satisfactory distribution. One of the dogs died five days after the injection of pantopaque and the pathologist reported the

pression that there is a difference in the tissue response to these three contrast media, lipiodol apparently appearing to be the most inert and pantopaque apparently producing a reaction with some acute inflammatory components as well as a foreign body reaction (Fig. 10*B*).

We hope to continue our studies of the

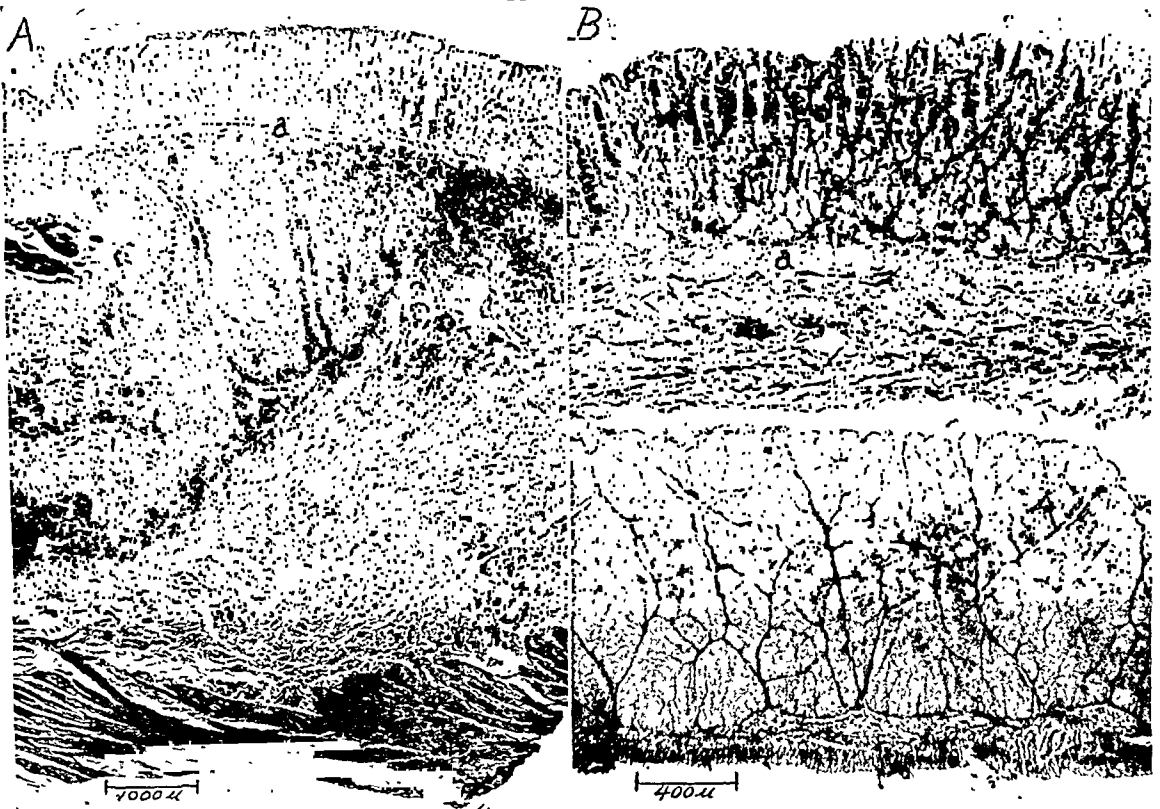


FIG. 8. *A*, low power ($\times 19$) photomicrograph of the anterior gastric wall of dog No. 222 (Fig. 2 and 4) thirteen months after thorotrast was injected into the submucosa. Marked thickening of the entire gastric wall, especially the submucosa, is apparent. There is also extensive necrosis. Muscularis mucosae is at (*a*). *B*, photomicrograph of the anterior gastric wall of a normal dog's stomach ($\times 53$). Note the appearance of the submucosa and compare with (*A*). Muscularis mucosae is at (*a*).

finding of an acute inflammatory reaction, apparently around the contrast medium (Fig. 10*A*). In order to further investigate this finding, we injected pantopaque into the gastric submucosa of 2 dogs and made similar injections of thorotrast and lipiodol into 2 other dogs. Biopsies were obtained after five days and the dogs were sacrificed after twenty-one days. Our results are not complete and we plan to make further studies but we have gained the initial im-

gastric mucosa and elicit further information concerning the behavior of the muscularis mucosae and its response to chemical and mechanical stimuli. This will form the subject of a later report.

SUMMARY

1. The anatomy and physiology of the gastric mucosa has been reviewed with particular reference to the muscularis mucosae and its ability to produce movements

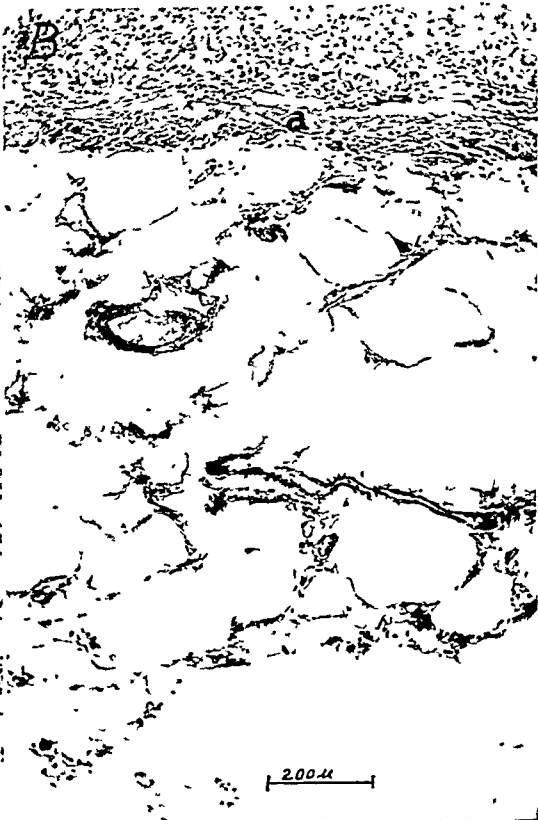
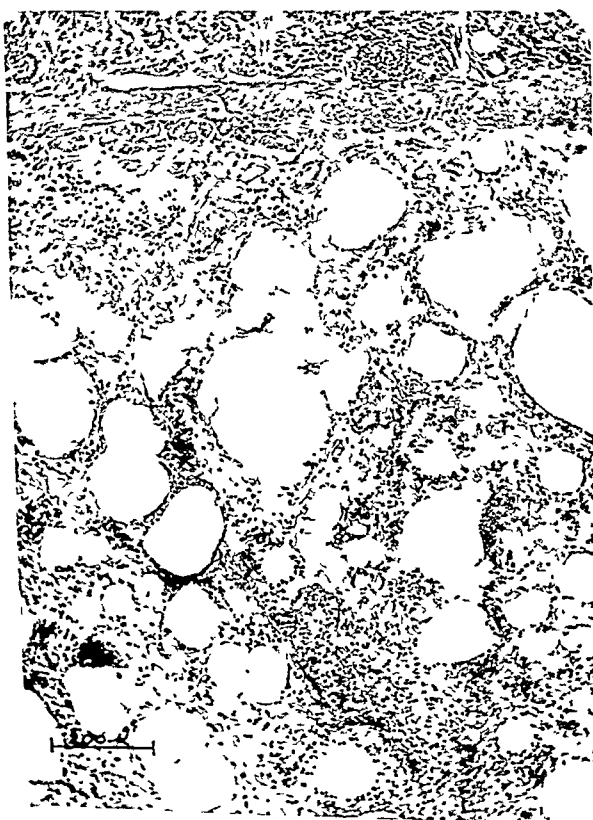
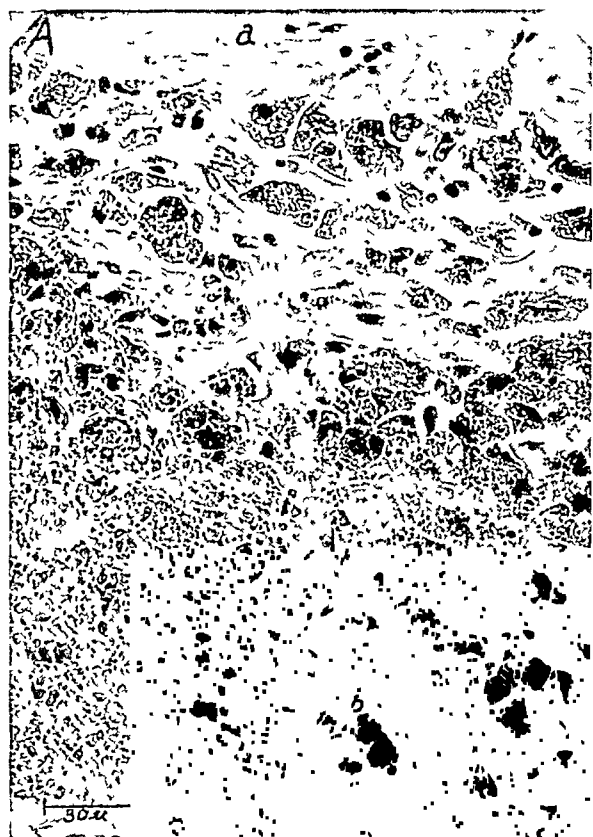


Fig. 9, top; Fig. 10, below. (See opposite page for legends.)

of the gastric mucosal folds.

2. Serial roentgenograms of dogs' stomachs, made after marking the curvatures with lead shot and the muscularis mucosae with thorotrast in the submucosa, have been presented to show movement of the mucosal folds, while the shot, representing the muscularis propria, remain relatively fixed in position.

3. Similar roentgenograms made after the subcutaneous injection of mecholyl show movement of both the muscularis propria and the mucosal folds.

4. The gastric mucosa is capable of movement due to contraction of the muscularis mucosae independently of the muscularis propria.

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REFERENCES

1. ALVAREZ, W. C. An Introduction to Gastro-Enterology. Third edition of Mechanics of Digestive Tract. Paul B. Hoeber, Inc., New York, 1940.

2. THE COLE COLLABORATORS. Radiologic Exploration of the Mucosa of the Gastro-Intestinal Tract. Bruce Publishing Co., St. Paul and Minneapolis, 1934.
3. FORSELL, G. Studies of mechanism of movement of mucous membrane of digestive tract. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1923, 10, 87-104.
4. FORSELL, G. Role of the autonomous movements of gastrointestinal mucous membrane in digestion. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1939, 41, 145-165.
5. GIANTURCO, C. Some mechanical factors of gastric physiology. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1934, 31, 735-750.
6. GOLDEN, R. Antral gastritis and spasm. *J.A.M.A.*, 1937, 109, 1497-1500.
7. GOLDEN, R. Radiologic Examination of the Small Intestine. J. B. Lippincott Co., Philadelphia, 1945.
8. KUNTZ, A. The Autonomic Nervous System. Third edition. Lea & Febiger, Philadelphia, 1945.
9. MORA, J. M. Granulomatous tumor following intramammary injection of colloidal thorium dioxide. *J.A.M.A.*, 1940, 115, 363-364.
10. STEGGERDA, F. R., and GIANTURCO, C. Method for visualizing different organs in normal unanesthetized animal. *Anat. Rec.*, 1937, 67, 405-407.



FIG. 9. *A*, high power ($\times 660$) of a portion of the area shown in Figure 8*A*. The muscularis mucosae is at (*a*). In addition to the necrosis, calcification is seen at (*b*). Macrophages filled with thorotrast particles are numerous. *B*, still greater magnification ($\times 1,200$) of a cluster of thorotrast laden macrophages. Same section as in Figures 8*A* and 9*A*.

FIG. 10. *A*, a low power ($\times 110$) photomicrograph of the anterior wall of a dog's stomach five days after the injection of pantopaque into the submucosa. The muscularis mucosae is at (*a*). Between the vacuolated spaces in the loose fibrous tissue is a moderately large number of polymorphonuclear leukocytes scattered and in groups. A small number of macrophages are present. The appearance is that of an inflammatory reaction of moderate degree and recent origin. *B*, a low power ($\times 110$) photomicrograph of a portion of the anterior gastric wall of a dog five days after the injection of lipiodol into the submucosa. The muscularis mucosae is at (*a*). There is virtually no reaction. The large vacuoles probably represent areas from which the lipiodol has been dissolved.



PRIMARY TUMORS OF THE SMALL INTESTINE*

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TUMORS of the small intestine have never occupied a prominent place in the differential diagnosis of diseases of the abdomen because of their infrequent occurrence. Also, until recently, there have been no good clinical methods of determining the existence or absence of a tumor of the small bowel.

Recent emphasis⁴ on the study of the small intestine by oral barium followed by serial roentgenograms until barium reaches the cecum has established the appearance of the normal intestine and the changes of the mucosal pattern and contour of the bowel which occur in many diseases. The passage of a Miller-Abbott tube has been of great help in these studies and roentgenograms made after the balloon of such a tube has been stopped by an obstruction serve to locate the lesion. Barium injected through the tube at this time often gives accurate information regarding the nature of the obstruction.

While using the above methods to exam-

TABLE I
OCCURRENCE OF SYMPTOMS IN 62 TUMORS
OF THE SMALL INTESTINE

	Gastro- intes- tinal Symp- toms	Abdom- inal Mass Only	No Signs or Symp- toms	Total
Carcinomas	9	0	3	12
Sarcomas	3	1	0	4
Malignant car- cinoids	0	0	2	2
Benign tumors	2	0	42	44

ine several patients with abdominal pain, two tumors of the small intestine were discovered. This prompted the present investigation to determine the incidence, types,

symptoms, and roentgenographic appearance of tumors of the small intestine, and whether a group of patients could be selected on the basis of symptoms in which the possibility of tumor was great enough to justify special examination of the small intestine. The latter point is very important because the time required to make the examination and the expense involved prohibit its use in every patient with symptoms of intra-abdominal disease.

The records of the University Hospitals of Cleveland for the years 1933 to 1946 include 62 cases of tumors of the small intestine. Eighteen malignant tumors were recorded and 13 of these caused symptoms referable to the gastrointestinal tract or had a palpable mass in the abdomen (Table I). The incidence was 1 tumor to 3,000 admissions on the surgical service, or 1 to 9,000 general hospital admissions.

BENIGN TUMORS

There were 44 benign tumors (Table I) and only 2 of these caused clinical symptoms. Both of these were pedunculated tumors which caused intussusception.

TABLE II
TYPE AND LOCATION OF 44 BENIGN TUMORS

Type	Duo- denum	Je- junum	Ileum	Total
Carcinoid	1	2	12	15
Adenomatous polyps	2	4	4	10
Lipoma	1	1	3	5
Lymphangioma	0	1	3	4
Leiomyoma	0	2	1	3
Hemangioma	0	1	1	2
Fibroma	0	2	1	3
Neurofibroma	0	1	0	1
Fibromyoma	0	1	0	1
	4	15	25	44

* From the Department of Roentgenology, University Hospitals of Cleveland, Ohio, and Western Reserve University Medical School.

Three benign tumors were incidental findings at operation when the abdomen was opened for some other reason. Thirty-nine of the benign tumors were incidental findings at autopsy. This was an incidence of about 1 per cent of the autopsies during this period.

Table II shows the cell types of the benign tumors, and the distribution of the tumors in the small intestine. Six of the tumors were pedunculated and varied from 5 mm. to 3.5 cm. in size. Eight of the remaining tumors were described as nodules which projected into the lumen of the bowel. They varied in size from 2 mm. to 2 cm., and caused slight to moderate narrowing of the intestinal lumen. Eleven of the tumors were intramural in location, and did not narrow the bowel. The exact location of some of the tumors in the wall of the intestine was not stated. Twenty-five of the 44 benign tumors were in the ileum, and 12 of these cases were carcinoids. (One case in which there were twelve carcinoids of the ileum and 2 with multiple lymphangiomata of the jejunum are recorded in this paper as single tumors.) Thirteen tumors were in the jejunum and 6 were in the duodenum.

The patients varied in age from one month to eighty-seven years, and the average age was slightly over fifty-two years. There were 29 males and 13 females.

Since the benign tumors described in this paper were found in autopsy material for the most part, no discussion of the symptoms or of clinical diagnoses of these tumors is possible. Rankin and Newell⁹ have reported 35 cases of benign tumors of the small intestine, of which 18 caused such symptoms as pain in 8 cases, "stomach trouble" in 3 cases, hematemesis in 3 cases, and melena in 1 case. A palpable tumor existed in 2 patients. Intussusception occurred in 6 of the 18 cases in which symptoms appeared. Seventeen of the 35 benign tumors were incidental findings at operation.

Resection of the benign tumors gives excellent results except in patients whose general condition is critical because of com-

plications such as intussusception or hemorrhage due to the tumor.

MALIGNANT TUMORS

The location and types of 18 malignant tumors of this series are shown in Table III. (Tumors of the ampulla of Vater are not included in this report.) Three of the tumors were found in the duodenum, 8 in the jejunum, and 7 in the ileum. There were 12

TABLE III
TYPE AND LOCATION OF 18 MALIGNANT TUMORS
OF THE SMALL INTESTINE

Type	Duo- denum	Je- junum	Ileum	Total
Carcinoma	3	5	4	12
Lymphosarcoma	0	2	0	2
Fibrosarcoma	0	0	1	1
Leiomyosarcoma	0	1	0	1
Malignant carcinoid	0	0	2	2
	3	8	7	18

carcinomas, 3 in the duodenum, 5 in the jejunum, and 4 in the ileum. Two lymphosarcomas and 1 leiomyosarcoma occurred in the jejunum. One fibrosarcoma and 2 malignant carcinoids were found in the ileum.

Age and Sex Incidence. The average age of 18 patients with malignant tumors was forty-eight years, and the age range was from twenty-one to seventy-six years. There were 10 males and 8 females. The 12 patients with carcinomas averaged forty-seven years of age with a range of twenty-seven to seventy-six years. There were 7 males and 5 females in this group. The patients with lymphosarcomas were males sixty-four and twenty-one years of age.

Symptoms and Signs. The chief complaints of 18 patients with malignant tumors of the small intestine were abdominal pain in 9 cases, vomiting in 2 cases, and diarrhea and weakness in 1 case each. Six had no symptoms referable to the gastrointestinal tract, although 1 of these patients had a large abdominal mass. His chief complaint was weakness.

Abdominal pain existed in 9 of the 18 cases for an average time of twelve months. Seven of the 12 patients with carcinoma had pain for an average time of seven months. The patients with the leiomyosarcoma and the fibrosarcoma had noted intermittent abdominal pain for three years and two years respectively. In most cases the pain was intermittent at first and occurred in attacks several days, or even several weeks, apart. It was usually centered in the epigastrium or around the umbilicus, but occasionally went "through to the back." Two patients described the pain as "dull." Four patients stated definitely that pain appeared only after a meal, and two avoided pain by not eating. In cases with constricting lesions of the intestine, the pain invariably became severe and often constant. Two patients who developed intussusception had several attacks of mild pain for ten weeks and five months respectively before the final episode of intussusception.

Nausea and vomiting occurred in 5 cases with an average duration of eleven weeks. In 4 of these cases, the lesions were in the duodenum or upper jejunum. Mild and intermittent diarrhea existed in 3 cases for an average of nine months and became severe in 1 of these for a period of three months. Two patients had occasional melena over a period of eight weeks in 1 case and almost three years in the other. Severe melena appeared as a terminal event in 2 additional patients as the immediate cause of death.

Intussusception occurred in 4 cases, but was not diagnosed clinically in 2 patients whose lesions were in the distal ileum. The presence of large tender abdominal masses, vomiting and abdominal pain permitted the correct clinical diagnosis in 1 patient and prompted exploration in the other patient with the diagnosis of intestinal obstruction.

The tumor was palpable as an abdominal mass in 6 patients and as a pelvic mass in another whose preoperative diagnosis was fibromyoma of the uterus. Two additional tumors of the jejunum were not discovered by palpation because of intussusception

which obscured the tumors although each was about 4 cm. in size. These tumors would probably have been palpable if intussusception had not occurred. Nine tumors were not palpable. Three of these were in the duodenum and 2 were in the lower ileum, and examination of these regions by palpation is often unsatisfactory.

Loss of weight was severe in most cases. Eight patients whose records were complete had an average weight loss of 26 pounds.

Gross Characteristics. Eight of the malignant tumors were infiltrating in type and 9 were polypoid. Three of the polypoid tumors were pedunculated. A carcinoma of the duodenum appeared as multiple papilliferous nodules 2 to 8 mm. in size. One of the carcinomas of the ileum infiltrated the bowel for 8 cm., and at the distal edge of the lesion there was a pedunculated tumor 2 cm. in size.

Necrosis of the tumor with ulceration and hemorrhage developed in 5 cases. Four of these were carcinomas and the other was a leiomyosarcoma.

The gross appearance of the various types of tumors has been recorded to permit correlation with symptoms and with diagnostic procedures. Seven of the 12 carcinomas in this series were infiltrating in type and 5 were polypoid or pedunculated. Five of the infiltrating tumors were severely constricting; 3 were completely annular tumors. Two of the infiltrating carcinomas extended along the wall of the bowel for 3 cm. and 8 cm. respectively, to cause no narrowing of the lumen in 1 instance and very mild obstruction in the other. Two of the 5 polypoid tumors were sessile masses 2 cm. and 3.5 cm. in size. The other 3 polypoid tumors varied from 2 cm. to 5 cm. in size, and had pedicles 1 to 3 cm. in length. The infiltrating tumors which constrict the intestine can be located by the use of the Miller-Abbott tube, and rarely cause intussusception. All cases of intussusception due to benign or malignant tumors reported in this paper were caused by pedunculated tumors.

Both of the cases of lymphosarcoma had

two foci of involvement. In 1 case there were polypoid masses 3 cm. and 4 cm. in size, separated by 50 cm. of normal bowel. Both were included in a long intussusception of the jejunum. The other case had an infiltrating tumor 16 cm. in length in which the lumen of the bowel was increased in diameter. A second similar lesion 5 cm. in length was found about 5 cm. distal to the larger mass.

The leiomyosarcoma of the jejunum was 8 cm. in diameter and decreased the caliber of the bowel only slightly. The surface of this tumor was ulcerated. The fibrosarcoma of the ileum measured 9.5 by 9 by 6 cm. in size and did not cause significant narrowing of the intestine.

Metastases. In the entire group of 18 malignant tumors, metastases or local extension to adjacent organs had occurred in 16 cases when the tumors were discovered. Distant metastases to the lung and brain were found in 1 case each before the primary tumors were discovered.

Ten patients with carcinoma of the small intestine were autopsied and had metastases to the following sites: mesenteric lymph nodes 8, liver 6, lungs 4, mediastinal lymph nodes 3, hepatic lymph nodes 2, brain 1, skeleton 1. There was local extension to the pancreas in 1 instance, and to the left kidney in another.

One of the patients with lymphosarcoma had no metastases at operation, and in the other case the mesentery was infiltrated to its base. No distant metastases were found. The leiomyosarcoma of the jejunum had metastasized to the mesenteric lymph nodes and to the serosa of the bowel in the form of many small nodules 2 to 3 mm. in size. The fibrosarcoma of the ileum had metastasized to mesenteric lymph nodes and to the liver.

Survival Periods. Six of the malignant tumors of the small intestine were discovered at autopsy. Twelve cases were operated upon and the average duration of life in this group was about 8.5 months. One patient is living and well twenty months after operation. No resection was done in 4 cases because of metastases or local exten-

sion of the tumor. These patients survived for two days, ten weeks, five and eight months respectively. The latter 2 cases had palliative procedures.

The tumors were resected in 8 cases, and regional lymph node metastases were found in 6 of these. The average duration of life for the patients with metastases was seven months. Two patients who had no metastases at operation lived for an average of twenty months.

Roentgenographic Changes. Eleven of the 18 patients with malignant tumors of the small intestine had plain roentgenograms of the abdomen or barium studies of the intestine. Upon review of the roentgenograms there are definite changes in 8 cases which might have led to a correct diagnosis if complete studies had been made. A diagnosis of carcinoma of the jejunum was made by the roentgenologist in 1 case, and lymphosarcoma was diagnosed in another. Both of these diagnoses were proved to be correct. The possibility of primary tumor of the intestine was mentioned in 3 other cases.

Plain roentgenograms of the abdomen showed "masses" in 2 instances due to intussusception in 1 case and to a large leiomyosarcoma in the other. Several other cases showed various degrees of gaseous distention of the small intestine.

Eight patients had barium studies. Four showed narrowed loops of small intestine; 2 had complete obstruction to the passage of barium through the jejunum; 1 showed dilatation of the intestine at the site of the lesion, and 1 patient had marked hypermotility. Case reports appear below to illustrate the roentgenographic changes.

CASE REPORTS

CASE 1. Patient was a white woman, aged twenty-eight, who was admitted to the hospital forty-eight hours after the onset of abdominal pain. Past history was negative. The pain had started at 1:30 A.M., and caused immediate vomiting. Morphine had not controlled the pain which became very severe, and vomiting was almost constant on admission to the hospital.



FIG. 1. Case I. Roentgenogram of abdomen made forty-eight hours after onset of abdominal pain. A 15 cm. mass of homogeneous density occupies the center of the abdomen and surrounding loops of small intestine are dilated. Note the absence of gas shadows within the mass. Intussusception due to adenomatous polyp of the jejunum.

Physical examination showed a large, tender abdominal mass which could not be examined satisfactorily because the patient writhed with pain. A roentgenogram of the abdomen showed a 15 cm. soft tissue mass with an abnormal amount of gas in surrounding loops of bowel (Fig. 1). At operation an intussusception of the jejunum was found. It was impossible to reduce the intussusception, and a 30 inch segment of bowel was resected. The patient made an uneventful recovery and was well seven years later. Examination of the surgical specimen showed that a polypoid tumor 3 by 2 by 2 cm. in size caused the intussusception.

Microscopic report: Adenomatous polyp of the small intestine.

Six tumors of the small intestine included in this report caused intussusception, and 4 were operated upon. Two of the tumors were benign and 4 were malignant tumors (adenomatous polyp, lipoma, lymphosarcoma and 3 carcinomas). In 2 patients intussusception and the tumors were unex-

pected findings at autopsy. The mass which is usually palpable and which appears on the roentgenograms as a shadow of increased density is composed of mesentery and loops of bowel which contain other loops of bowel and fluid but no gas. If the lesion is high in the jejunum, there may be almost complete decompression of the proximal intestine by vomiting. If the lesion is lower in the intestine, gas and fluid levels appear in the proximal bowel.

CASE II. Patient was a white woman, aged fifty-one, who complained of continuous epigastric pain and vomiting of six weeks' duration. She had lost 26 pounds in the last four weeks.

Past history revealed that intermittent epigastric fullness and discomfort, and mid-scapular aches and pains had existed for over two years. The patient had obtained relief with castor oil.

Physical examination showed the upper half of the abdomen to be distended by what was



FIG. 2. Case II. Patient with two year history of epigastric fullness and back pain. Severe vomiting for six weeks. Roentgenogram made six hours after oral barium shows dilatation of the jejunum just beyond the ligament of Treitz (A), with a filling defect (B) at the distal end of the dilated segment (see Fig. 3).

believed to be a dilated stomach. Peristaltic waves passed over this mass almost continuously. The region was extremely tender to palpation.

Roentgenograms made after a barium meal showed moderate dilatation of the stomach, duodenum, and upper jejunum (Fig. 2). The duodenal bulb measured 7 cm. in width and 12 cm. in length. Only a small amount of barium passed into the distal loops of jejunum in six hours.

At operation an annular, constricting lesion of the jejunum was found 25 cm. beyond the ligament of Treitz. The tumor was 2.5 cm. in length (Fig. 3). A 40 cm. segment of bowel and enlarged mesenteric lymph nodes were resected. She was readmitted nine months later with recurrent abdominal pain. An ileostomy was performed and there was widespread abdominal carcinomatosis. She died three months after the operation.

Microscopic diagnosis (surgical specimen): Adenocarcinoma of the jejunum, with metastases to mesenteric lymph nodes.

This case illustrates unusually severe symptoms of two years' duration. If the abdominal pain had been investigated earlier by a small intestinal study, it is conceivable that the diagnosis might have preceded the metastases to the mesenteric lymph nodes.

The roentgenogram is quite typical of dilated small intestine due to a chronic obstruction. The bowel contains a large amount of fluid into which a relatively small amount of barium has passed. Three other similar cases occurred in this series.

CASE III. A white woman, aged forty-five, complained of upper abdominal pain, nausea, and vomiting of seven months' duration. She was admitted to the hospital for cholecystectomy. A routine gastrointestinal study showed several wide and incomplete rugae in the upper jejunum (Fig. 4). A mass was palpable in this region, and further study of the intestine was performed by the passage of a Miller-Abbott tube. The tip of the tube stopped 12 cm. beyond the ligament of Treitz. Barium was injected through the tube and showed an irregular constricting lesion of the jejunum with a lumen only 8 mm. in diameter. Carcinoma of the jejunum was suggested (Fig. 5).



FIG. 3. Case II. Adenocarcinoma of the jejunum, 2.5 cm. in length and completely annular. The jejunum is dilated proximal to the tumor.

At operation the tumor appeared as a hard nodular mass which extended along the mesentery to greatly enlarged lymph nodes. There were metastases in the liver. After a biopsy of the tumor, a gastroenterostomy was performed. The patient lived about five months after the operation.

Microscopic diagnosis (biopsy): Poorly differentiated mucinous adenocarcinoma of the jejunum.

This case illustrates the use of the Miller-Abbott tube to locate and study loops of small intestine which do not appear normal in routine examinations. Four carcinomas of this series showed this type of deformity of the intestine.

Very similar deformities have been observed since this paper was submitted, in a lymphosarcoma of the jejunum, and due to localized regional enteritis of the ileum.



FIG. 4. Case III. Patient had epigastric pain and vomiting for seven months. Abnormal mucosal folds and filling defects were noted in a routine gastrointestinal study. It was impossible to determine if the changes represented an intrinsic or extrinsic lesion of the bowel without special studies (see Fig. 5).



FIG. 5. Case III. Barium was injected through the Miller-Abbott tube after the balloon was stopped about 12 cm. beyond the ligament of Treitz. An irregular, narrow segment of jejunum about 3.5 cm. in length is visualized. The barium column is tortuous and normal mucosal markings are absent. The changes are typical of carcinoma which was proved by surgical exploration and biopsy.

CASE IV. The patient was a male, aged sixty-four, whose complaints were unusual fatigue and anorexia of seven months' duration, with inability to swallow normally, and 37 pounds loss of weight. Laboratory and clinical studies gave normal findings. On the routine gastrointestinal series, a slightly enlarged loop of bowel was noted low in the abdomen, but the patient was discharged from the hospital the same day.

It was five weeks before the patient returned for further study. A Miller-Abbott tube was passed and the balloon stopped 45 cm. beyond the ligament of Treitz. Barium injected through the tube showed a lesion 15 cm. in length, with an increased diameter of the lumen, "pebbled" mucosal markings in the diseased portion, and a sharp transition from a normal to an abnormal mucosal pattern. A second, smaller lesion appeared 5 cm. beyond the first one (Fig. 6).

A diagnosis of lymphosarcoma of the jejunum was made and proved by operation and microscopic examination. The entire mass

which was resected was oval in shape, 25 by 15 cm. in size. The wall of the bowel was 2 to 4 cm. in thickness (Fig. 7). It was impossible to remove all of the tumor because of extensive involvement of the base of the mesentery. Postoperative roentgen irradiation was administered with the 400 kv. apparatus to three anterior abdominal fields. A tumor dose (calculated to the posterior abdominal wall) of 2,400 r was planned, but the patient tolerated irradiation poorly and only two-thirds of the course was given. He gained strength very slowly, but is still living and well twenty months after the operation.

Microscopic diagnosis (surgical specimen): Lymphosarcoma.

The case illustrates the detailed study of the mucosa of a lesion of the small intestine which is possible with a Miller-Abbott tube. Zimmer,¹³ in 1923, emphasized that lymphosarcoma often causes an increase in the caliber of the bowel, while carcinoma of the

small intestine is usually a constricting lesion. The sharp transition from normal to abnormal mucosal markings is strong evidence for tumor and against inflammation. The "pebbled" surface markings of the tumor and the multiple foci of involvement with normal bowel between are

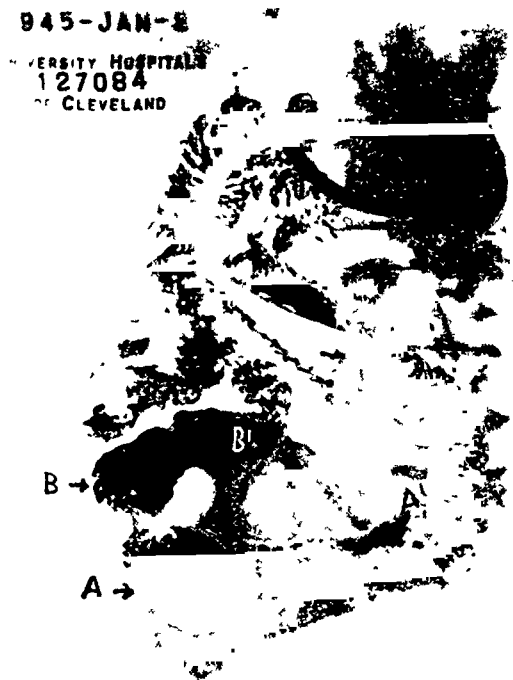


FIG. 6. Case iv. Patient had anorexia, weakness and weight loss for seven months. No abdominal pain. The Miller-Abbott tube stopped about 30 cm. beyond the ligament of Treitz. Barium studies show two lesions of the jejunum at *AA'* and *BB'*. The lesions are 15 cm. and 5 cm. in length respectively, and are separated by a 5 cm. segment of normal intestine. The lumen of the intestine is increased in diameter and the mucosal markings are pebbled. There is a sharp transition from normal to abnormal mucosal markings. Lymphosarcoma of the jejunum.

additional features indicating lymphosarcoma.

CASE v. A male, white, aged fifty-two, complained of severe paroxysms of coughing of several weeks' duration, and repeated hemoptysis for several days. He had lost more than 20 pounds of weight during the past five months, and unusual fatigue had developed during this time. A chest roentgenogram showed a mass in the base of the left lung meas-



FIG. 7. Case iv. Cut section of large lymphosarcoma of the jejunum. Note thickness of the intestinal wall and the nodular mucosal surface. There is no ulceration and the lumen of the bowel is slightly increased in diameter.

uring 10 by 9 by 8 cm. in size. Bronchograms showed displacement of bronchi of the left base. Aspiration biopsy was diagnosed as carcinoma simplex.

The tumor in the base of the left lung was irradiated from anterior, lateral, and posterior fields, and received a tissue dose of about 4,000 r. The tumor decreased in size during this time, but the patient became very weak. Six days



FIG. 8. Case v. Patient had hemoptysis from a metastatic carcinoma of the lung. At autopsy three months later an unsuspected 3 cm. pedunculated carcinoma of the ileum had caused a very tight intussusception (*b*). The tumor (*a*) was necrotic and hemorrhage was the immediate cause of death.



FIG. 9. Case VI. Obstruction of the jejunum, about 10 cm. beyond ligament of Treitz. There is no characteristic deformity of the bowel and normal mucosal markings persist to the very point of obstruction. Adhesions caused this obstruction, but an annular carcinoma might produce similar roentgenographic changes.

after the patient went home following radiation therapy, he was readmitted with severe intestinal hemorrhage. He died in eight hours. Autopsy showed a 2 cm. pedunculated tumor of the terminal ileum which caused a very tight intussusception with necrosis of the tip of the tumor, and severe hemorrhage (Fig. 8).

Pathological diagnosis: Pedunculated polypoid carcinoma simplex of the ileum with intussusception. Metastases to abdominal and mediastinal lymph nodes, the lungs, liver, trachea, pleura, vertebrae, and ribs.

This case is typical of 3 carcinomas of the small intestine which caused no symptoms. Two had symptoms due to cerebral and lung metastases, and hemorrhage from the primary tumor was the immediate cause of death in 2 cases. Two metastasizing carcinoids caused no symptoms.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of lesions of the small intestine which produce roentgenographic changes must include deformities

and constriction of the bowel due to (a) adhesions, (b) extrinsic tumors and inflammatory masses, (c) inflammatory processes such as regional enteritis, tuberculosis, and non-tuberculous ulcers, and (d) lesions of the mesentery deforming the intestine.⁹

Adhesions are the first possibility to be considered in all patients who have had abdominal operations. If signs of severe intestinal obstruction exist, oral barium is, of course, contraindicated; such cases are often surgical emergencies. Less severe cases may be treated by the Miller-Abbott tube which decompresses the intestine and permits careful study of the nature of the obstructive lesion when acute symptoms are controlled. Adhesions show constriction of the bowel with proximal dilatation, and constricting malignant tumors may produce the same picture. If the abnormal segment of bowel is studied by injection of barium through a Miller-Abbott tube, the tumors often show irregular narrowing for a distance of 3 to 6 cm., while the defects are smooth and the lesions are usually shorter than when due to adhesions (Fig. 9).

Extrinsic masses may cause smooth or irregular constrictions of the intestine which are indistinguishable from the picture of an intrinsic tumor or adhesions causing obstruction. It is sometimes possible to determine that only one lateral wall of the bowel is involved by an extrinsic tumor; however, in one case of endometriosis of the ileum studied by barium injected through a Miller-Abbott tube the deformity was symmetrical.

The history and physical examination must be depended upon to help exclude extrinsic tumors or inflammatory masses. A history consistent with a post-appendiceal abscess, the presence of ascites suggesting peritoneal metastases from an ovarian tumor, or an increase in symptoms with menstruation would influence the evaluation of a deforming lesion of the small intestine.

Regional enteritis may appear as a classical constricting lesion many centimeters in length, or as a nodular and

irregularly narrowed segment of bowel of almost any length. The latter type (Fig. 10) simulates diffuse lymphosarcoma of the intestine (Fig. 11). Carcinoma rarely extends along the bowel for more than 4 to 6 cm., although one case of the present series was 8 cm. in length, and Golden mentions a carcinoma of the terminal ileum which was 15 cm. in length.

Tuberculous lesions are usually many centimeters in length, and the usual involvement of the cecum in this condition would suggest the correct diagnosis. Golden reports a non-tuberculous ulcer of the ileum which was 2 cm. in length as an example of a "short" lesion which would be very misleading in the attempt to make a roentgenographic diagnosis of carcinoma of



FIG. 10. Case VII. A woman, aged thirty-four, had recurrent episodes of abdominal pain for seven years. Three attacks were accompanied by subcutaneous nodules on the legs, diagnosed erythema nodosum. Two abnormal loops of jejunum cross the central abdomen. Normal mucosal markings are absent and nodular masses cause filling defects (1). The caliber of the bowel varies with narrow segments (2) and proximal dilatation (3). This patient had regional enteritis. Diffuse lymphosarcoma of the intestine may produce a similar picture.



FIG. 11. Case VIII. Patient, aged forty-two, had diarrhea, weakness, weight loss and anemia of five years' duration, but improved with vitamin therapy and continued to work until two months before death. Small intestinal study shows extensive deformities of the jejunum and ileum due to masses in the wall of the intestine, and thick mucosal folds. Note similarity to Case VII. Autopsy: Lymphosarcoma (stem-cell lymphoma), with diffuse involvement of the jejunum, ileum and mesentery.

the intestine on the basis of the length of the lesion. A sharp transition from normal to abnormal mucosal markings in such a case would increase the difficulty of correct diagnosis, for a majority of the inflammatory lesions have indeterminate margins by roentgenographic examination.

The differential diagnosis of the various primary malignant tumors may be considered superfluous; however, certain interesting observations have been made. Carcinoma of the jejunum is the most common malignant tumor, and lymphosarcoma of the ileum is next in incidence. The carcinomas generally occur as irregularly constricting lesions 3 to 6 or 8 cm. in length, and lymphosarcomas may be similar.

However, it has been emphasized that lymphosarcomas often cause dilatation of the lumen of the bowel and frequently develop to a large size of 10 to 15 cm. before causing severe clinical symptoms. The pebbled or corrugated surface pattern of the mucosa of the bowel as seen by a barium study is quite characteristic of lymphosarcoma. Both lymphosarcomas and plasmocytomas of the small intestine may involve multiple segments of the bowel.¹¹ Many instances of neurogenic sarcoma, fibrosarcoma, and leiomyosarcoma of large size have been reported with mild or no obstruction of the intestine, while large carcinomas which do not obstruct the intestine are rare.

DISCUSSION

The case histories and the characteristics of the tumors of the small intestine described in this paper are in general very similar to those of other series which appear in the literature.

The incidence of malignant tumors of the small intestine has been found to vary from 0.5 to 6 per cent of malignant tumors of the gastrointestinal tract,¹¹ and Ewing³ gives an incidence of 3 per cent. The incidence of these tumors at the University Hospitals of Cleveland was 2.1 per cent of malignant tumors of the gastrointestinal tract below the esophagus. McDougal⁶ collected 300 cases of malignant tumors of the small intestine in 1944.

Intussusception has been reported in 4 per cent of malignant tumors of the small intestine and in 17 to 30 per cent of the benign tumors.^{8,9} The incidence in the present series of 18 cases of malignant tumors was slightly over 20 per cent, and in the 4 benign tumors only 5 per cent. The low incidence of 5 per cent intussusception in 44 cases of benign tumors is not inconsistent with other reports because most of the tumors of this series were incidental findings at autopsy.

The operative mortality rate varies from 20 per cent⁵ to 40 per cent,¹⁰ and 2 post-operative deaths occurred in 12 cases of this series which were operated upon. The

five year survival rate has been very low in all series of malignant tumors of the small intestine. Emmett and Dreyfuss² state that 5 per cent survived five years, and Mayo and Nettrour⁵ had 2 patients living and well at the end of seven years. There was 1 three year survival in the present series, and 1 patient is living and well at the end of twenty months.

Certain features responsible for the poor end results in every series reported and possible methods of improving the results will be discussed.

Metastases or extension to adjacent organs had occurred in 10 of the 12 cases which were operated upon and existed in all of the remaining 6 cases in which the tumors were discovered at autopsy. Shallow, Eger and Carty¹⁰ state that 31 cases in a series of 38 malignant tumors of the small intestine had metastases when the tumors were discovered. Earlier diagnosis is essential to permit treatment before the tumors have metastasized. It is stated in the literature that tumors of the small intestine are usually rapid in development and metastasize early. This view is not justified because the long duration of symptoms which is repeatedly mentioned indicates that many of the tumors have existed for months or years before diagnosis. The presence of metastases does not seem unusual.

Abdominal pain has been reported as the dominant symptom in all large series of malignant tumors of the small intestine and existed for an average time of twelve months in 9 of the 18 cases reported in this paper. In 7 cases of carcinoma which had pain as the chief symptom the average duration of pain was seven months. An examination of the small intestine during this period would have permitted earlier diagnosis in several of these cases in which the tumors were constricting in type.

Two patients had melena which was intermittent over a period of three years in 1, and for eight weeks in the other patient. The passage of a Miller-Abbott tube with aspiration of intestinal contents as the tube moved along and testing the aspiration

material for blood would have located the level of the bleeding point in the intestine. Abbott¹ has suggested that such a patient be prepared for surgery when this type of examination is started so that an immediate operation can be performed before the tip of the tube moves away from the bleeding point.

The poor end results in the management of malignant tumors of the small intestine are due to late diagnosis and the degree of malignancy of these tumors. When the rather long duration of symptoms mentioned above is considered, earlier diagnoses would appear to be possible in many instances. Patients who have intermittent or persistent abdominal pain of unusual duration, or persistent vomiting, melena, or diarrhea which remains undiagnosed after routine examinations of the gastrointestinal tract, gallbladder, and kidneys, should have special studies of the small intestine to exclude a primary tumor. To this group should be added the cases of unexplained abdominal masses if every effort to obtain an accurate preoperative diagnosis is desired.

There remains a group of tumors of the small intestine which cause no symptoms or signs of their existence until after they have metastasized. There were 5 such tumors in the present series of 18 cases; 3 were carcinomas. These cases cannot be diagnosed unless by some chance the entire small intestine is explored manually when the abdomen is opened for some other reason.

Treatment of malignant tumors of the small intestine will not be discussed in this paper except to say that surgical resection is the treatment of choice. The lymphosarcomas should receive postoperative high voltage roentgen irradiation to the central abdomen to include the entire mesentery and retroperitoneal lymph nodes. This is the only treatment which can be employed in extensive or diffuse involvement of the intestine by lymphosarcoma.

SUMMARY

1. Sixty-two cases of tumors of the small intestine were collected from the records of

the University Hospitals of Cleveland in a period of thirteen years and analyzed with special reference to symptoms and roentgenographic appearance.

2. There were forty-four benign tumors of which only two caused symptoms. These were cases of intussusception produced by pedunculated tumors. Three of the benign tumors were incidental findings at operations performed for other purposes. Thirty-nine of the benign tumors were discovered at autopsy. This was an incidence of about 1 per cent of the autopsies during this period.

3. Eighteen malignant tumors were recorded and twelve of these were carcinomas. Five of the carcinomas were in the jejunum, four were in the ileum, and three were in the duodenum. There were two lymphosarcomas; both were in the jejunum. The other malignant tumors were one leiomyosarcoma of the jejunum, one fibrosarcoma, and two malignant carcinoids of the ileum.

4. The chief symptoms of the malignant tumors were abdominal pain, vomiting, melena, diarrhea, and weakness. By far the most important symptom was abdominal pain which had existed in one-half of the cases for an average time of twelve months. Seven of the twelve cases of carcinoma had abdominal pain for an average of seven months. The tumors were palpable in nine of the eighteen cases. There were no signs or symptoms in five cases.

5. Roentgenographic examination showed evidence of a lesion of the small intestine, upon review of the roentgenograms, in eight of eleven cases which were examined. The diagnosis of primary tumor of the small intestine was made twice, and the possibility of that condition was mentioned in three additional instances. Eight patients who had barium studies showed the intestine to be dilated by the lesion in one case, irregular narrowing of the intestine in four cases, complete obstruction to the passage of barium in two cases, and marked hypermotility in one case.

6. Twelve patients with malignant tumors of the small intestine were explored

surgically, and ten had metastases or local extension of the tumors to adjacent abdominal organs. The average duration of life of the twelve cases which were operated upon was eight and one-half months. Resection was performed in six patients who had metastases and the average duration of life of this group was seven months. Two patients, who had no metastases when the tumors were resected, lived five months and thirty-six months respectively. There were two postoperative deaths.

7. The poor results in the management of these cases are due in part to the difficulties of diagnosis of the tumors. Fairly typical symptoms existed in about 65 per cent of the cases for several months, and such patients should have special examinations of the small intestine. Unexplained abdominal masses should be similarly studied.

8. Patients who have persistent abdominal pain, either intermittent or constant, and patients with vomiting, melena, or diarrhea which remains undiagnosed after routine studies of the gastrointestinal tract, gallbladder, and urinary tract, deserve special study of the small intestine to exclude a primary tumor. The small intestinal examination should consist of a barium meal followed by frequent fluoroscopic study and serial roentgenograms as barium passes through the intestine.

9. Carcinoma of the small intestine characteristically causes an irregular constriction of the bowel, 2 to 6 centimeters in length, with a tortuous column of barium through the lesion. Lymphosarcomas can occasionally be identified because the lumen of the tumor is larger than the normal intestine. Many of the primary tumors have no special roentgenographic picture, and the duty of the radiologist is to locate the lesion as "obstruction of unknown cause."

10. There is a group of malignant tumors of the small intestine, such as five of the present series of eighteen cases, which defies diagnosis. These cases do not give a

typical history, cause no obstruction or bleeding and no abdominal mass can be palpated because the tumors are small or are located in portions of the abdomen where palpation is unsatisfactory.

The author expresses appreciation to Dr. Frank Gibson, Dr. S. O. Freedlander, Dr. Robert Heinle, Dr. J. G. Wilmore, Dr. R. R. Renner, and Dr. F. R. Mautz for permission to use their cases in this report.

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REFERENCES

1. ABBOTT, W. O. In: *Advances in Internal Medicine*. J. Murray Steele and others, Editors. Vol. I. Interscience Publishers, Inc., New York, 1942.
2. EMMETT, J. M., and DREYFUSS, M. L. Malignant tumors of the small bowel. *Ann. Surg.*, 1946, *123*, 859-865.
3. EWING, J. *Neoplastic Diseases: A Treatise on Tumors*. Fourth edition. W. B. Saunders Co., Philadelphia, 1941.
4. GOLDEN, R. Radiologic Examination of the Small Intestine. J. B. Lippincott Co., Philadelphia, 1945.
5. MAYO, C. W., and NETTROUR, W. S. Carcinoma of the jejunum. *Surg., Gynec. & Obst.*, 1937, *65*, 303-309.
6. McDUGAL, W. J. Carcinoma of the small intestine. *Am. J. Surg.*, 1944, *66*, 119-122.
7. McSWAIN, B., and BEAL, J. M. Lymphosarcoma of the gastrointestinal tract; report of 20 cases. *Ann. Surg.*, 1944, *119*, 108-123.
8. O'DONOGHUE, J. B., LICHTENSTEIN, M. E., and JACOBS, M. B. Primary adenocarcinoma of the jejunum with intussusception. *Am. J. Surg.*, 1944, *63*, 382-387.
9. RANKIN, F. W., and NEWELL, C. E. Benign tumors of the small intestine. *Surg., Gynec. & Obst.*, 1933, *57*, 501-507.
10. SHALLOW, T. A., EGER, S. A., and CARTY, J. B. Primary malignant disease of the small intestine. *Am. J. Surg.*, 1945, *69*, 372-383.
11. SWENSON, P. C. X-ray diagnosis of primary malignant tumors of small intestine. *Rev. Gastroenterol.*, 1943, *10*, 77-91.
12. WEBER, H. M., and KIRKLIN, B. R. Roentgenologic manifestations of tumors of small intestine. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, *47*, 243-253.
13. ZIMMER, F. Beitrag zur Lymphosarkomatose des Magen-Darmkanals. *Med. Klin.*, 1923, *19*, 681.

CAVERNOUS HEMANGIOMA OF THE FRONTAL BONE

WITH REPORT OF A CASE OF SINUS PERICRANII

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HEMANGIOMAS are neoplasms composed of newly formed blood vessels. They occur in several clinical forms with varying characteristics. They may appear as (1) superficial elevated or non-elevated discolorations of the skin or (2) as deeply situated non-elevated or elevated tumor formations, either circumscribed or diffuse.

Cavernous hemangioma differs from the simple type in that when not encapsulated it may spread and destroy the neighboring tissue, including cartilage and bone. These neoplasms may develop soon after birth. They are usually deep-seated, lobulated, blue or purple tumors, occurring most often in the scalp, face and mouth. In the later states they involve the tongue, lips and gums. When deep-seated they may be covered by normal epidermis. The growth is potentially, with the aid of gravity, radially expansive, producing a globular type of tumefaction. Cavernous hemangioma may metastasize to the lungs, spleen, liver, bone marrow and other tissues, even in its microscopically benign form.

Sinus pericranii is a specific type of cavernous hemangioma of the pericranium which may or may not communicate by emissary or adventitious vessels through abnormal foramina into the skull with the dural sinuses. In some cases, when associated with hemangiomata of the cerebellum or retina, it may be part of a syndrome known as the von Hippel-Lindau syndrome. Often the hemangiomatous process involves the underlying bone slightly or widely. As a rule, it is congenital in origin and appears as a soft, compressible, fluctuant swelling, which increases in size with increase in venous pressure or by the aid of gravity. It

is seen most frequently over the forehead, and less often along the sagittal sinus and over the occiput.

A brief résumé of the gross anatomy of the cranial vault is necessary in order to understand and be able to translate the roentgen signs into pathological changes. The thickness of the frontal bone varies greatly within normal limits in different individuals. It usually averages about 5 mm. in thickness. The bone is composed of two compact layers, the external plate about 1.5 mm. in thickness and the internal plate 0.5 mm. in thickness. Separating the two plates is a layer of cancellous bone filled with red bone marrow, the diploe (about 3 mm. thick), which contains the diploic canals of Breschet through which course the diploic veins. These veins are divided into local systems named after the bone in which they are situated. After synostosis of the cranial sutures these systems intercommunicate.

MICROSCOPY

The simple form of hemangioma consists of a network of dilated capillaries and vessels situated chiefly in the papillary layer of the corium. The vascular spaces vary in size and shape and have thin, endothelium-lined walls. There is some cellular infiltration in the deeper portions of the corium including the presence of mast cells. The overlying epidermis is usually thin and delicate but may be normal in the very deeply situated tumors.

The cavernous form shows numerous vascular sinuses connected by connective tissue septa. In certain areas these septa are obliterated by pressure or cystic dilatation.

When malignant, there are signs of proliferation, invasion and metastases.

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FIG. 1. Photographs before surgery.

ETIOLOGY

The intrauterine theory of Unna is the best. It is supported by the occurrence of congenital hemangiomas in regions where the fetal skin, such as over the frontal and occipital regions, comes in contact with the bony prominences of the maternal pelvis.

Virchow's fissural theory is supported by the occurrence of these lesions most abundantly in the positions of the early fetal clefts.

The Pollitzer theory claims that they result from compression of the cutaneous vessels from an unusual degree of flexion or extension of the head and limbs.

ROENTGEN EXAMINATION

The roentgen examination frequently demonstrates abnormal openings in the skull and often phleboliths which may be palpated in the mass when the blood has been drained or expressed by pressure. In



FIG. 2. Comparative photographs after surgery.

others, simple honeycombing or actual irregular destruction of the underlying bone is noted.

In the skull, the lesion appears as a more or less localized area of decreased bone density, containing a serpiginous or racemose type of vascular network in the diploe. The lesions may undermine the inner and outer tables, but do not widen these. Later, as a result of pressure and growth, both tables of the calvarium may become eroded.

DIFFERENTIAL DIAGNOSIS

In the absence of spicule formation, no difficulty should be encountered in the differential diagnosis from meningioma. The benign lesions may undergo malignant degeneration to form angioendothelioma. In its early stage it may still closely resemble the benign form. Later, the irregular increasing dilatations of the regional vascular channels in size and number, the extensive irregular bone erosion, the roughening and the new bone formation appear.

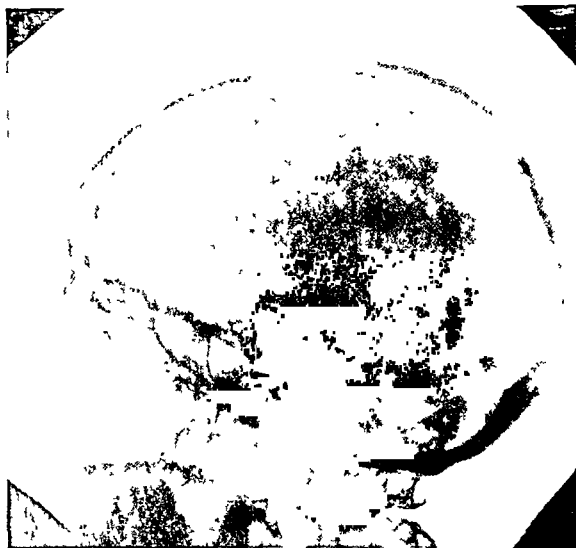


FIG. 3. Lateral view. Note the irregular honeycombing of the frontal bone, underlying the lesion seen clinically.

TREATMENT

1. Surgery
2. Radiation therapy (external)
3. Sclerosing therapy, using 7 per cent sodium morrhuate. The needle is introduced into the vascular space and suction is applied until blood is obtained. A few drops to about 5 cc. are injected. Manual compression is maintained until a rubber sponge pressure bandage has been applied.
4. Surgery plus sclerosing therapy
5. Surgery plus carbon dioxide snow
6. Surgery plus electrocautery
7. Surgery plus implantation of radon seeds
8. Combinations of the above methods, with or without the use of tantalum foil.

CASE REPORT

A male, aged twenty-nine, began to notice a soft pliable swelling under the skin of his upper mid-forehead, approximately six years prior to admission. The swelling gradually increased its flat dimensions. Another swelling appeared three years ago in the left frontotemporal region just lateral to the first mass. Both swellings became increasingly prominent and developed bulging with bluish discoloration on coughing or straining or with the head forward in a dependent position. For the past year the patient

had noted a depression in his skull beneath the central swelling, which had become slightly tender on firm pressure. There were no headaches, pulsatile throbbing, tinnitus or visual symptoms.

Examination revealed a healthy appearing male of average build with moderately plethoric facies. Vital signs were normal. Blood pressure at rest and with postural variation averaged 128/76 in all limbs. General physical status, including appraisal of the heart and lungs, was normal. A roentgenogram of the chest was normal. Routine laboratory studies were normal, including bleeding and clotting time. Localized bluish swellings under the skin and scalp were observed as shown in the preoperative photographs of the patient. A shallow deepening in the outer table of the skull was palpable beneath the upper of the two swellings at the hair-line. Both masses distended rapidly and showed cyanosis of the overlying skin on voluntary strain or jugular compression. Simple skull roentgenogram and those made during injection of the tumefactions with 35 per cent diodrast are illustrated in figures and described elsewhere.

Operation (Dr. Hannibal Hamlin): Under so-



FIG. 4. Tangential view. The same area is seen in profile. There is no diploic widening. The outer and inner tables are partly eroded.

dium pentothal anesthesia a left paramedian subgaleal scalp flap was turned down in a frontolateral direction by aponeurotic dissection, exposing the pericranium. A bulbous and furrowed mass 3.5 by 4.5 cm. presented to the left of the midline, which was non-pulsatile but compressible and obviously contained venous blood. Several large tributary veins were seen draining its margins and an irregular shaped sinus connected the central portion with a smaller but similar sinus over the left frontotemporal region. The periosteum was tissue-thin or absent over both lesions, and grooving of the outer cranial table was palpable beneath the larger one. The major tributary veins were ligated with silk. Following the technique described by Ebin^{1,2}, a block of CO₂ snow was applied repeatedly with pressure over various parts of the tumor for periods up to sixty seconds. The areas compressed became glazed with frost and were obliterated, but rapidly thawed and re-expanded after removal of the solid CO₂. The larger sinusoidal portions invariably returned to the same size, color and consistency within two or three seconds.

A total of 5 cc. of sodium morrhuate was injected in divided amounts at several points of the lesion. A sheet of tantalum foil was then laid over the entire mass prior to closure of the



FIG. 6. Appearance after 8 cc. of diodrast has been injected.

galeal-skin flap. A pressure dressing completed the procedure.

Pathological Report (Dr. Shields Warren): Hemangioma. There is considerable fibrosis of the tissue, and although histopathologically a cavernous type, the blood spaces are not large. There is no evidence of the tumor being malignant.

Comment. Recovery was uneventful. Six months after operation there was no external evidence of recanalization of the tumor. Failure to obliterate the hemangioma by CO₂ snow application can probably be attributed to the prompt return of a large volume of blood by way of numerous interconnecting channels into the main reservoirs of the tumor. Immediately after contact with the freezing agent had ceased, a rapid temperature rise ensued which produced quick thawing of the affected tissues. Firm pressure of the CO₂ block was maintained for periods up to one minute as recommended; but alternate use of the electrocautery, an essential step in the proposed technique, was not tried because of the rapidity with which the blood spaces

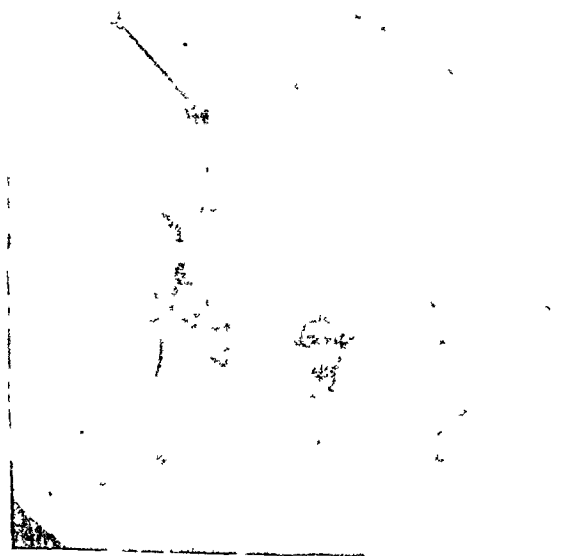


FIG. 5. Appearance of the lesion after 5 cc. of 35 per cent diodrast has been injected directly. Note the extensive diploic venous ramifications. The opacified channels correspond to the irregular honeycombing seen in the simple roentgenogram.

thawed and refilled and for fear of perforating their thin walls.

The insertion of subgaleal tantalum foil will facilitate dissection in the proper plane should re-exposure of the lesion become necessary. Future treatment might contemplate either reinjection of sclerosing solution or the implantation of radon seeds.

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REFERENCES

1. EBIN, J. Carbon dioxide snow-electrocautery technique for occlusion of large veins; suggested application to venous angioma of brain. *Surg., Gynec. & Obst.*, 1943, 76, 43-50.
2. EBIN, J. Carbon dioxide snow-electrocautery technique for occlusion of arteries; suggested application to arteriovenous angioma of brain. *Surg., Gynec. & Obst.*, 1943, 76, 456-459.
3. FERGUSON, J. K. *Surgery of the Ambulatory Patient*. J. B. Lippincott Co., Philadelphia, 1944.
4. PEYTON, W. T., and LEVEN, N. L. Hemangioma and its treatment. *Surgery*, 1938, 3, 702-718.



ATLANTO-OCCIPITAL FUSION, OSSICULUM TERMINALE AND OCCIPITAL VERTEBRA AS RELATED TO BASILAR IMPRESSION WITH NEUROLOGICAL SYMPTOMS

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VARIOUS examples of bony distortion about the foramen magnum were reported by early anatomists,^{2,5,8,9,14-17,20,21,22,25,28,34-37,40,45,47} a total of some 93 cases in all. The clinical significance of these changes has been appreciated in this country since a paper by Chamberlain in 1939. The reports in English now total 52 cases with 44 operated upon, while Peyton and Peterson have collected 26 additional cases in the foreign literature, 6 of them operated upon.

There are two principal types of congenital anomaly: atlanto-occipital fusion, first described by Rokitansky in 1844 and demonstrated roentgenographically by Schüller in 1911, and the manifestation of occipital vertebra described first by Meckel in 1815 and again by Kallman in 1905. To these must be added those cases of acquired basilar impression or invagination secondary to softening of the skull base from osteitis deformans, osteogenesis imperfecta⁴¹ osteomalacia, rickets, and also, as mentioned by one author,³¹ lipoidosis, senile osteoporosis, osteopsathyrosis congenita and cleidocranial dysostosis.

Neurological symptoms, if present, may be mistakenly diagnosed as indicating multiple sclerosis, spastic paralysis, amyotrophic lateral sclerosis, cerebellar or upper cervical canal tumor,⁶ Klippel-Feil syndrome, hydrocephalus, or syringomyelia. In fact, the last two may coexist with the basilar impression.

Since early decompression of the foramen and upper cervical region offers some hope of arresting the destructive process in the central nervous system, a lateral survey roentgenogram of the upper cervical spine made in full forward flexion is indicated in all cases showing neurological symptoms of

upper cord degeneration or compression. Fay¹² suggests a review of the so-called multiple sclerosis group, some of those cases previously diagnosed syringomyelia or multiple sclerosis having been discovered, upon examination, to be cases of basilar impression.

One and possibly 2 of the following 6 cases show elements of an occipital vertebra; the others are examples of atlanto-occipital fusion.

CASE REPORTS

CASE 1. B. D., a well developed, well nourished, intelligent, cooperative schoolgirl, aged eleven, was first examined on September 28, 1942. The principal complaint was weakness for the past half year. Play with other children tired her quickly. The child became upset easily and, when nervous, developed hiccough or nausea and vomiting. At no other time was there nausea and vomiting nor did the child complain of dizziness or headache. There had been occasional "shooting pains" down the anterior surface of the left thigh. The mother stated that the left eye watered when the hair was being brushed above the left side of the forehead, but not on the right side.

There was no unilateral sweating, flushing, or other sympathetic imbalance. Both pupils were of the same size and reacted to light and accommodation. There was no nystagmus and the vision was normal. The movements of the tongue were normal, strong and well coordinated.

The child had some spasm of the right sternomastoid muscle, the head was carried to the right side, and there was limitation of rotation of the neck to the left. Temperature and tactile perception were normal on both sides of the face and on the entire right side of the body. On the left side, however, beginning in the scalp there was a marked hypesthesia to both tactile and pain stimuli. Heat perception was entirely

lost on the left side and cold produced a painful sensation interpreted as heat.

Arm reflexes were exaggerated on the right and normal on the left. The abdominal reflexes were present on the right side and absent on the left. Right patellar reflex was exaggerated, the left normal. The right mid-thigh was smaller than the left, measuring 14 and 15 inches in

examination of the cervical spine revealed the following:

1. A complete atlas of normal appearance, the arch not fused with the occiput.
2. Normal articulations between the atlas and occiput in the anteroposterior view.
3. Flexion-extension studies showed some movement between the atlas and occiput. The

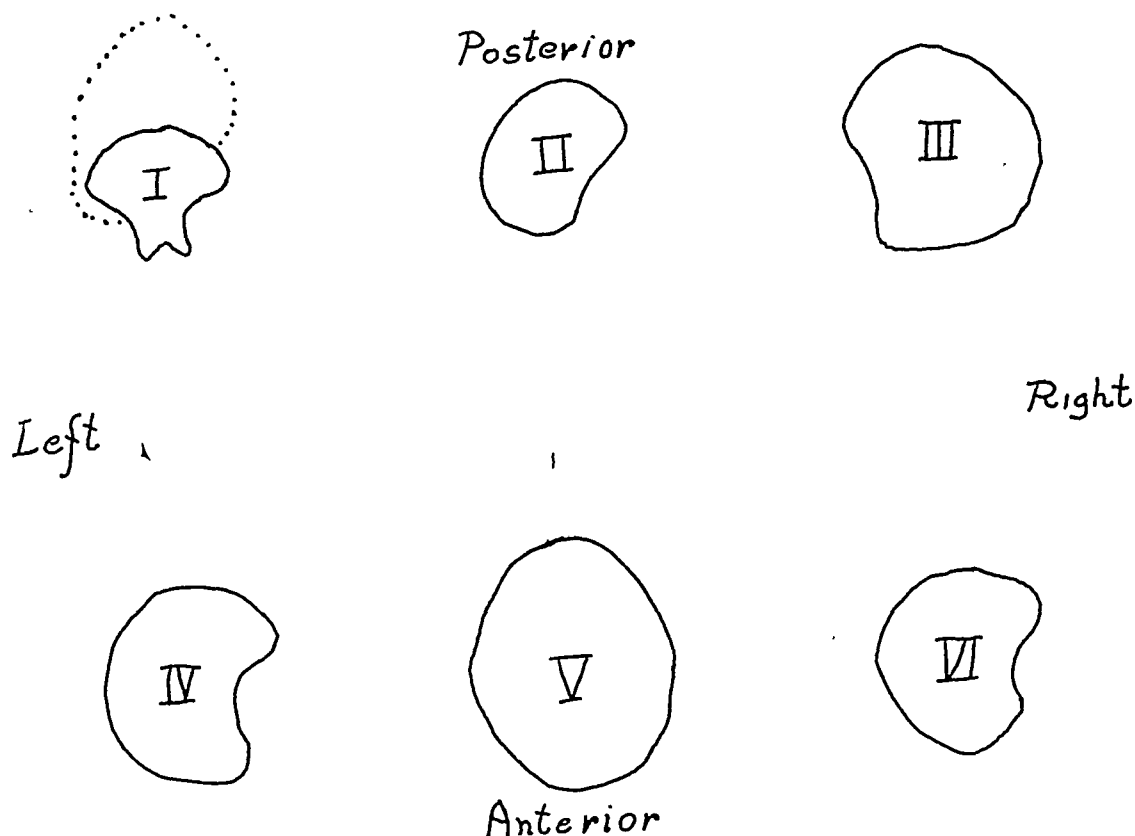


FIG. 1. Foramen magnum tracings from each of the 6 congenital cases. Case v is normal but there is unilateral encroachment upon the anterolateral margins of Cases II, III, IV and VI and bilateral in Case I. In the latter the dotted line shows the outline of the foramen four years after operation.

circumference respectively. Both Achilles reflexes were weak. There was a strongly positive Babinski reflex on the left and a questionable one on the right. Ankle clonus was observed on the left but not sustained. There was no Romberg's sign but coordination was somewhat disturbed, the child being unable to touch the great toe with the opposite hand when the eyes were closed. In a Bárány whirl chair test, normal past pointing was obtained.

Roentgen Studies. In addition to six lumbar segments with bilateral sacralization of the lowermost, incomplete development of the left fifth posterior lumbar articulation and a moderate lower dorsal scoliosis to the left, roentgen

flexion-extension studies consist of two lateral films of the cervical spine—one in extreme dorsal extension and the other in extreme ventral flexion. Normally these reveal gliding of the vertebral bodies forward and backward on each other as well as the approximation and separation of the spinous processes. The arch of the atlas becomes separated from the occiput in the forward flexed position.

4. The odontoid process was much shorter than normal and slightly broadened.

5. The posterior margin of the foramen magnum was thinned and projected downward below its usual level.

6. The outline of the foramen magnum as

studied on the stereoscopic axial films was seen to be shaped somewhat like a bicycle seat (Fig. 2). The posterior third seemed normal but the anterior portion was distorted, being encroached upon on each side by bony masses projecting from each margin of the foramen about one-third of the way across.

7. The narrow space in front was partly occupied by a small oval-shaped ossicle entirely separate from and slightly above and behind the odontoid, the so-called ossiculum terminale (Fig. 3). It originates from the notochord in the terminal ligament of the odontoid and normally may form the tip of that structure. Embryologically, however, it represents the body of the occipital vertebra.

These various changes combined to constrict the foramen magnum to about one-half its normal size.

Operation. At operation, on November 4, Dr. Ward Williams exposed the first and second cervical arches and lower occiput. Laminectomy of the atlas showed the arch to be somewhat less dense than normal. At the midline in back, the edge of the foramen magnum was thin and smooth. Lateral to the midline, however, a small cornu was present on each side. These represented the rudiments of the posterior arch of the occipital vertebra. They were removed

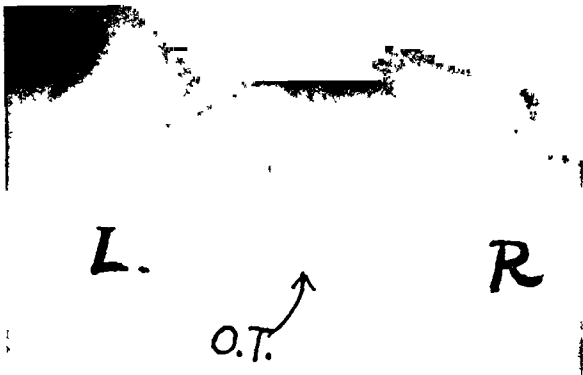


FIG. 2. Case 1. Preoperative foramen crossed by arch of the atlas. Tip of ossiculum terminale (O. T.) visible in the narrowed anterior portion of the opening.

and the foramen magnum was enlarged.

A circular fibrous constriction of the dura was uncovered at this level similar to that described by List. As this was dissected away, there was a progressive expansion of the dural sheath to its normal diameter. An incision was made in the dura and the wound closed after hemostasis.

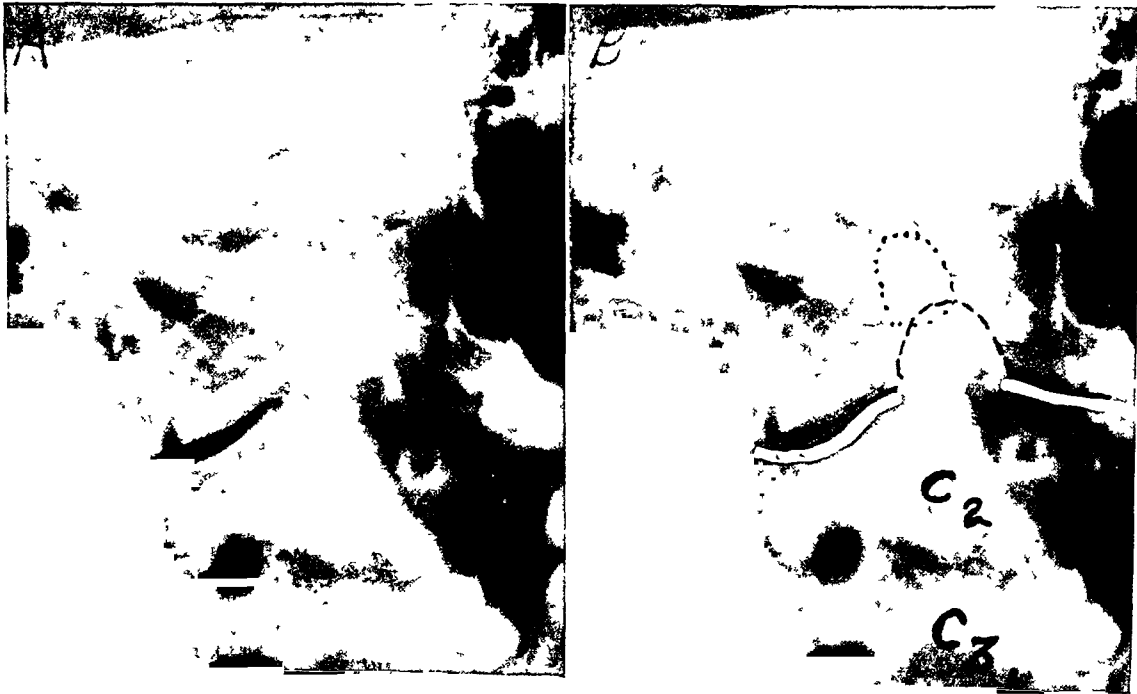


FIG. 3. Case 1. A, Kasabach position, described in text, showing odontoid and ossiculum terminale. B, articular surface of axis shown by full white line. Short stubby odontoid—dash line. Ossiculum terminale slightly overlying odontoid—dotted line. Compare with A.

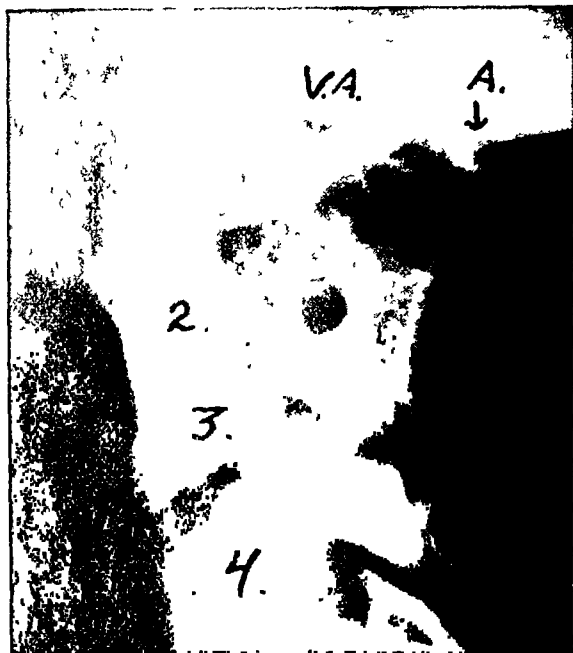


FIG. 4. Case II. Arch of the first segment (*A*) fused to the base. This segment has features of an atlas on the left side and occipital vertebra on the right. Foramen for vertebral artery (*V.A.*). Block vertebra below this with features of second and third segments and a short odontoid. Rudimentary rib (not shown) on left side of eighth cervical body (counting block vertebra as two and three).

Recovery was uneventful and the child returned home on the twelfth day. Two months after operation she had returned to school. The Babinski reflex was no longer present, but the other neurological signs remained unchanged.

Five years later the clinical picture is still unchanged. The only new symptom is an increase of the scoliosis. She walks with very slight incoordination but maintains scholastic leadership in her class at school.

This case was briefly reported in a previous communication.¹⁹

CASE II. A. C., male, aged fifteen, was hospitalized for neuromyelitis optica. There was bilateral nystagmus. Reflexes were essentially normal except for inconstantly diminished left ankle and left biceps. The boy has bilateral congenital clubfoot and the middle phalanges of all fingers are short.

Roentgen examination shows eight cervical segments of which the second and third are fused into a block vertebra, their transverse processes being perforated for the vertebral

arteries. There is a rudimentary cervical rib on the left side of the eighth body.

Fused to the base of the skull is the first segment, having some features of an atlanto-occipital fusion on the left side and the characteristics of an occipital vertebra on the right. Such a condition has been described¹⁵ on the skull from a woman eighty-five years of age.

Projecting above the block vertebra is a very short odontoid, directed slightly toward the left side, which articulates with a third condyle on the anterior margin of the foramen magnum. The ossification center for the tip of the odontoid is not yet completely united.

The presence of this rudimentary odontoid process as a projection from the cephalic aspect of the block vertebra marks that segment of the block as actually the second cervical segment (axis).

The jugular foramina are unusually large.

CASE III. M. G., female, aged twelve, has had fixed torticollis since birth, no other symptoms or neurological signs. Abdominal, patellar and Achilles reflexes normal, no Babinski reflex, no incoordination of arms or legs nor sensory disturbance. Tongue movements normal, no nystagmus.

Roentgen examination revealed atlanto-occipital fusion and slight evidence of basilar impression. The fused cervical segment was above the Chamberlain line but the basic angle

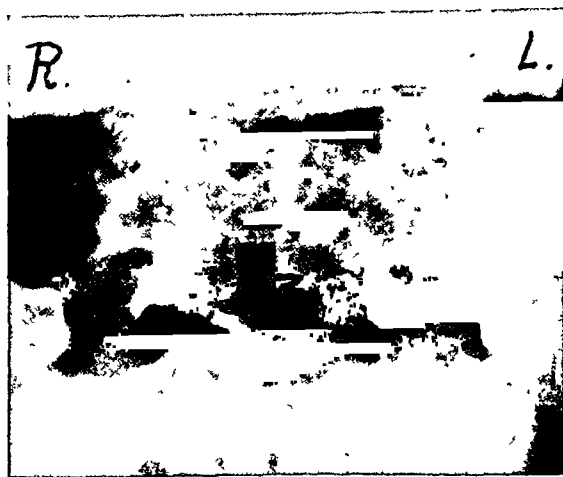


FIG. 5. Case II. Asymmetrical block vertebra, as shown by dorsal projections through the open mouth. Some degree of basilar impression is present, since the rudimentary odontoid process is seen to lie cephalad to its normal position as shown by this view.

(medial floor anterior fossa and clivus) was 135° (normal 135° to 150°). There was non-segmentation between the second and third as well as the sixth and seventh cervical segments (Fig. 6).



FIG. 6. Case III. Anterior flexion. Posterior arch of atlas (white arrow) fused to occiput. Unsegmented block vertebrae 2-3 and 6-7. First dorsal body somewhat elongated. Epiphyseal plates of vertebral bodies still present and there are elements suggestive of these structures actually within the 6-7 block vertebra.

The foramen magnum was distorted in shape, being higher and somewhat narrowed on the left side in front.

The torticollis results from asymmetry of the fused first segment. This was thicker on the left



FIG. 7. Case IV. Floor of cerebellar fossa elevated (arrow). Odontoid still incompletely fused with body of axis (patient three years old). Cervical arches closely approximated as normal for dorsal extension. Compare with Figure 8.

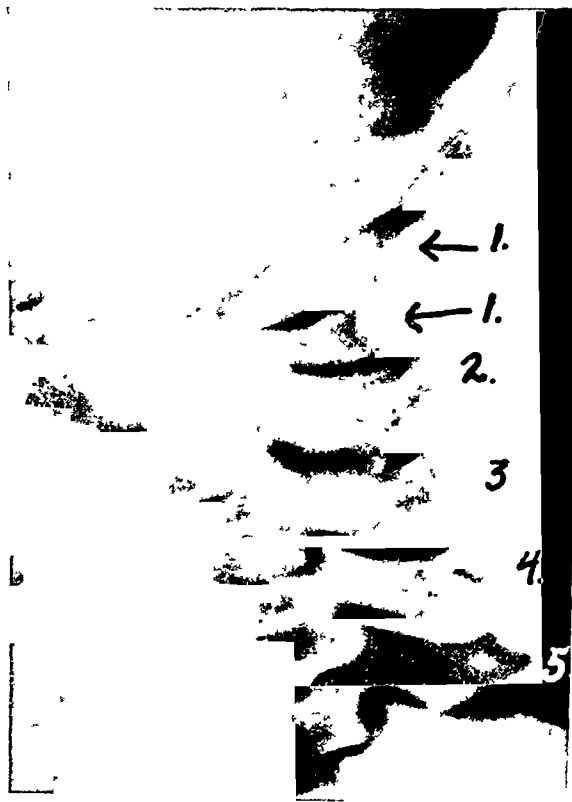


FIG. 8. Case IV. In forward flexion. Note that the cervical arches have now all become separated in the usual manner. The two sides of the atlas, however, are entirely separate. One side only is fused to the occiput while the other side is free. In forward flexion, therefore, the two sides of the first arch do not lie alongside of each other.

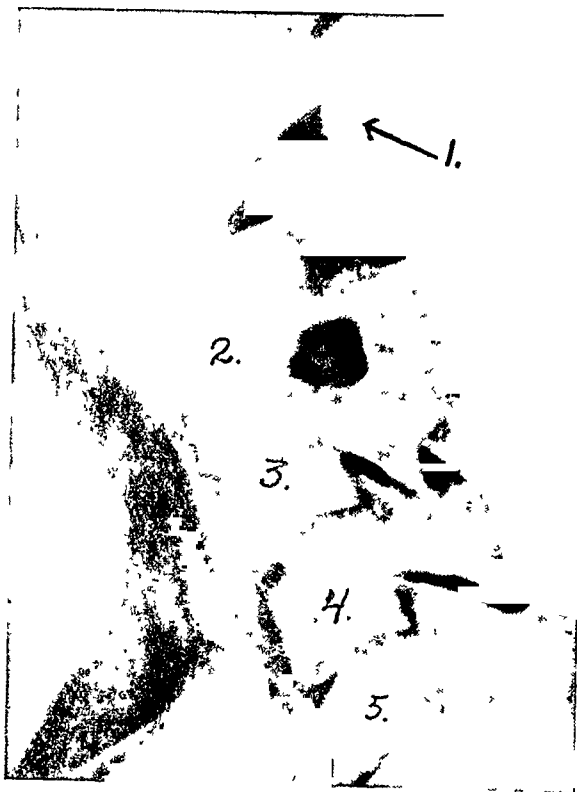


FIG. 9. Case v. In anterior flexion showing arch of atlas (white arrow) fused to occiput. The second and third bodies are unsegmented. This block vertebra is higher on the right causing a tilt of the head toward the left side.

side than on the right with the odontoid process angulated toward the right. This patient had a clubfoot at birth. She and her parents have been advised to be on the alert for the first appearance of any neurological signs.

CASE IV. R. J., male, aged three, no symptoms, condition discovered during examination for foreign body. This child has atlanto-occipital fusion (or non-segmentation) on one side only. The opposite side is freely movable in a normal manner. The two sides of the atlas are not united. Cases of unilateral fusion and non-union of the two sides of the atlas have been reported by anatomists.^{9,17} The true condition in this patient was revealed by a comparison of the flexion and extension studies (Fig. 7 and 8).

There is an asymmetrical encroachment of the foramen magnum. It is logical to believe that this child will probably develop symptoms as he becomes older and his parents have been told of this possibility.

CASE V. C. C., aged forty-four; patient in an automobile accident, no pertinent neurological symptoms. Anteroposterior studies through the mouth reveal a fusion of the atlas and occiput. Flexion-extension studies of course show complete fixation at this level (Fig. 9).

There is also non-segmentation of the second and third cervical bodies and their arches. This mass or block vertebra of the fused second and third bodies is higher on the right side, causing a tilt of the head to the left. There is no distortion in the shape of the foramen magnum. This is an older patient having no spinal cord pressure who has remained free of symptoms.

CASE VI. P. L., aged fifty-one; automobile accident. There were no significant neurological symptoms. Roentgen examination revealed an atlanto-occipital fusion and also a non-segmentation of the fifth and sixth cervical segments. The fifth intervertebral foramina showed the characteristic roundness noted in cases of congenital synostosis. Flexion-extension was fixed at the atlanto-occipital junction.

The cervical spine was inclined toward the left above the unsegmented fifth and sixth level. The right side of the axis was elevated with the odontoid directed toward the left side. Since the left side of the fused lateral mass of the atlas was much higher than the right side, the head could be carried in a level position. The

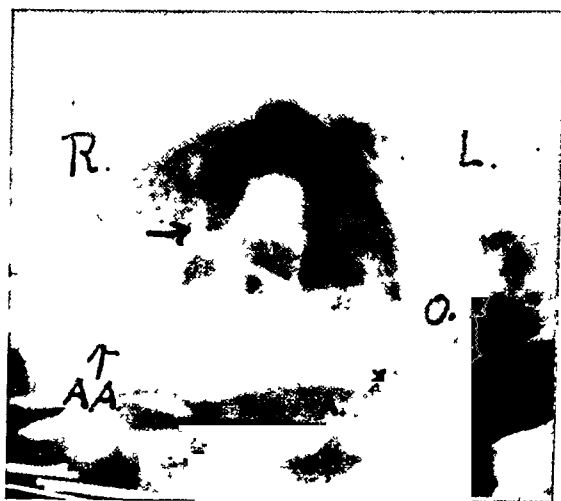


FIG. 10. Case vi. Atlanto-occipital fusion. Right side of foramen encroached upon (arrow) but the odontoid is in the midline. Atlanto-axial articulations (A. A.) normal but no atlanto-occipital articulations although inner surface of occiput (O) on left side simulates such a structure.

foramen magnum showed right-sided encroachment (Fig. 10).

DISCUSSION

Of these cases of congenital anomaly, Case I is an occipital vertebra, Case II has features of both, while the others are undoubtedly atlanto-occipital fusion. Five of the cases show asymmetry with tilting of the head. This is a very common condition reported by various anatomists.^{9,16,20,34} Ten of Dwight's 14 cases were asymmetrical,

Functional adaptation of the vertebral elements occurs at the various spinal regions such as: resorption of half the original ten coccygeal segments, movable fifth lumbar on the supporting fixed sacrum, short ribs at the dorsolumbar region, and the atlas with its centrum fused to the axis as the odontoid to allow rotation. The hypochondral arch of the atlas (elsewhere suppressed) is strongly developed to form the anterior arch of that bone. Its dorsal spinous process is absent to permit free rotary

TABLE I

Anomaly	Case I	Case II	Case III	Case IV	Case v	Case vi
Foramen distortion	Both sides	Right side	Left side	Right side	None	Right side
Basilar impression	o	+	+	++	o	++
Torticollis	++	+	+++	o	++	++
Basal angle	120°	135°	135°	120°	140°	120°
Fused segments	L ₆ -S ₁	C ₂₋₃	C ₂₋₃ C ₆₋₇	o	C ₂₋₃	C ₅₋₆
Other conditions	Undeveloped lumbar articulation	Clubfoot brachydactylism	Clubfoot	o	Short neck low hair-line	o

some with distortion in the shape of the face, others with rotation of the atlas on the axis or torticollis as in Cases I and III. The atlas may be displaced laterally or forward on the axis,^{1,12,18} and List reports a fatal case of forward dislocation of the atlas wherein the odontoid had compressed the spinal cord to a band 3 mm. wide and 2 mm. thick.

Non-segmentation, as in 4 of these cases, is common at various levels below the atlas and produces a tilting of the neck when the block vertebra is higher on one side. Fusion may even be so extensive as to constitute the Klippel-Feil syndrome, a somewhat related condition. There are likely to be anomalies elsewhere (Cases I, II and III). Lanier has reported a case of atlanto-occipital fusion with a hemivertebra for the left side of the axis while the right side with the odontoid was fused to the third cervical segment.

Table I gives a comparative tabulation of anomalies.

movement and its upper surface articulates with the oval convex condyles of the occiput to permit nodding movements.

At any of these transition points the characteristic functional modification may be displaced in a cephalic or caudal direction. Witness the sacralized lumbar vertebra, rudimentary ribs at the dorsolumbar level, cervical ribs, and lastly, two types of segmental shift at the top of the spine—atlanto-occipital fusion and occipital vertebra.

Embryology. Three phases in the development of the spine are recognized (1) blastemal or membranous; (2) chondrogenous; (3) the bony stage. Segmented groups of cells form about the notochord very early; lighter staining cells in front and darker ones in the caudal part of each segment or sclerotome. In the chondrogenous stage the cephalic (lighter staining) half of one sclerotome unites with the caudal half of the segment ahead to form a vertebra. The atlas, however, includes three half seg-

ments, i.e., all of the first cervical sclerotome and the cephalic half of the second cervical.

In the early stage there is no division between the spine and the skull. The sclerotomes or somites which later form the vertebrae are directly continuous in front with three or four postotic segments, the hypoglossal or occipital. In the chondrogenous stage these segments form the occipital plates and later fuse to form the continuous occipitosphenoid cartilage. Within this develop the four or five centers of the occipital bone which surrounds the foramen magnum. Solger has stated that distinct bones can be developed in a continuous uninterrupted piece of cartilage.

If the posterior-most hypoglossal sclerotome is incompletely assimilated with the others forming the base of the skull, an occipital vertebra results. This is said to be a normal condition in certain mammals of the weasel tribe such as the wolverine. If segmentation is not completed between the occiput and atlas, a so-called atlanto-occipital fusion results.

These errors of segmentation may result from diminished vitality of the germinal cells, thus interfering with the hereditary or growth power of the fetus. Schiffner, in speaking of this unstable condition of non-segmentation of the atlas, asserts that it is the result of a chronic disturbance of nutrition during development, which causes an arrest of the growth of the atlas. He adds that this applies to the fifth lumbar and sacrum or to any adjacent vertebrae. Most of the cases are congenital. Hayek found assimilation of the atlas in the human embryo and in newborn infants.

Rarely fusion of the atlanto-occipital joints may result from disease: arthritis, osteomyelitis, echinococcosis, syphilis, tuberculosis and actinomycosis being mentioned by Bézi in this connection.

In an 18 mm. fetus one may see the cartilaginous segments separated by the intervertebral disc tissue. The notochord passes as a continuous structure through the bodies and discs and upward through the odontoid and into the basal cartilage plate. As the vertebral bodies grow, the residual notochord substance becomes crowded into the adjacent intervertebral discs forming part of the nucleus pulposus.

At about the age of four or six years a separate ossicle forms about that portion of the notochord residuum, within the terminal ligament, just cephalic to the odontoid. This normally becomes united to form the tip of the odontoid about six years later. According to some authorities, it corresponds to the body of the last (hypoglossal) segment. If such union does not take place, this element may remain as a separate bony structure, the so-called ossiculum terminale, lying within and deforming the foramen magnum (Fig. 3). Such a condition is here reported in Case I showing a short stubby odontoid and a separate oval-shaped ossicle. Comparative anatomists believe this corresponds to the proatlas of the crocodile family.

Ossiculum terminale is not to be confused with non-union of the odontoid to the body of the axis, the so-called os odontoid-eum reported by various authors^{9,14,32,49} and by others as absent odontoid.^{42,44,51} These patients have a broad flat tubercle on the upper surface of the body of the axis but the odontoid is separate and may lie within the foramen magnum, as in List's case, or it may be attached to the anterior arch of the atlas. Dislocation of the atlas on the axis is the usual complication.

Another related condition to be differentiated is the third condyle first described by Meckel in 1818 and since by various anatomists.^{2,8,28,34} This appears as a tubercle or an articular facet on the anterior margin of the foramen magnum (Case II). It develops as an ossification within the terminal ligament or crucial ligaments and may articulate with the odontoid or the anterior arch of the atlas. Specimens 13 and 14 mm. in length have been reported.

Two other anomalies of clinical significance arise from abnormal ossification of ligamentous structures in this region. The first is the paramastoid process—a bony

articulation between the base of the skull and the transverse process of the atlas.^{2,9,15,34} This is probably congenital (one case discovered by Dwight in a child aged nine months), and usually induces asymmetry in the posture of the head and neck.

Of greater importance are the accessory eminences described by Le Double and others as masses of bone lying along the anterolateral borders of the foramen magnum. They may be bilateral or unilateral and are believed to originate by ossification of the anterior portion of the atlanto-occipital ligament. They cause encroachment upon the foramen magnum. Excellent illustrative examples are shown by anatomists,^{2,5,8,9,14,15,16} and Custis described the condition as bony "ramps" which he removed at operation. In Case I here reported the condition is bilateral, while Cases II, III, IV, and VI show it on one side only (Fig. 1 and 14).

Porticulus posticus is a condition without clinical significance arising from ossification of the posterior portion of the atlanto-occipital ligament and often seen on lateral projections of the cervical spine. It is a bony bridge extending from the posterior margin

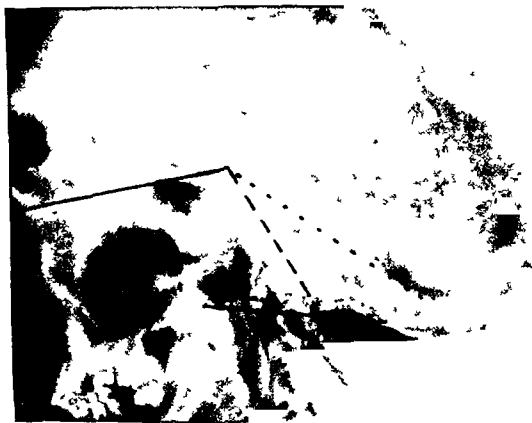


FIG. 11. Acquired basilar impression secondary to Paget's disease. The basilar angle measured in the midline to the anterior margin of the foramen magnum (dash line) is only about 110° . This is increased to 135° if measured to the floor of the elevated posterior fossa (dotted line). This is an advanced case of basilar impression or invagination with the atlas well above the Chamberlain line (C.L.), but not platybasia.



FIG. 12. Acquired basilar impression secondary to Paget's disease. The sine curve (dotted line elevated in front) replaces the normal downward curve of the floor of the cerebellar fossa

of the superior articular surface of the atlas backward to the upper margin of the posterior arch of this bone. It encloses the foramen arcuale (posterior atlantoid foramen) through which pass the suboccipital nerve and the vertebral artery. Hayek²¹ considers this a congenital rest from the cephalic half of the first cervical sclerotome.

Certain authors^{9,27,39} have reported a congenital condition of some possible medicolegal importance in post-traumatic cases; i.e., absence of the sides of the posterior arch of the atlas. The medial portion of the arch may be present. Macalister reported a case in which one side was missing. Cases were also reported by Dwight and Geiple wherein the anterior arch of the atlas was absent.

Characteristics of the Occipital Vertebra. The atlas is present and the malformations surround the foramen magnum. There may be a hypochondral arch, partially or completely fused to the anterior margin of the foramen magnum. This may bear a third condyle for articulation with the odontoid. This condyle may be either an articular depression or a single tuberosity with an articular facet. Bilateral bony masses or accessory eminences may encroach upon

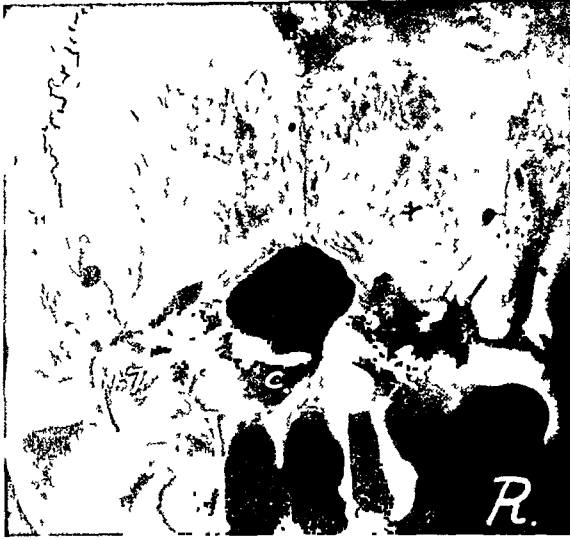


FIG. 13 Specimen showing asymmetrical atlanto-occipital fusion and asymmetrical basilar impression. The atlas is to the left of its normal position and the floor of the cerebellar fossa is elevated only on the right side (X). Note condyle (C) on the anterior arch of atlas for articulation with the odontoid and with an open space between it and the anterior margin of the foramen magnum. Each transverse process (T) bears a foramen for the vertebral artery. Note asymmetry of the foramen magnum with elevated margin as in Case III.

the anterior part of the foramen magnum as in Case I. These various bony tuberosities and masses develop in the ligamentous tissue about the foramen. A partial or complete neural arch may be outlined about the dorsal surface of the foramen. Transverse processes may or may not be present, more or less fused with the bones of the skull. If present, they do not bear a foramen for the vertebral artery. The condyles resemble those of the normal subject and an ossiculum terminale may be present as in Case I.

Characteristics of Atlanto-Occipital Fusion. Of differentiating value is the shape of the condyles. On the occipital vertebra these are oval and convex and in the anteroposterior view their articular surfaces face laterally in a caudal direction. The condyles on the undersurface of an assimilated atlas, however, are flattened (rarely slightly convex) and their surfaces visualized in the anteroposterior view are directed medially in a caudal direction.

In a case of atlanto-occipital fusion the articulation above the atlas is lacking on one or both sides. Flexion-extension studies will reveal a fixation of movement between atlas and occiput. The transverse processes bear foramina for the vertebral arteries. There is a space between the dorsal arch of the atlas and the occiput for passage of the suboccipital nerve and the vertebral artery. There is an articulation on the anterior arch for the odontoid. As with the occipital vertebra, the accessory eminences on one or both sides may encroach upon and distort the foramen magnum. The anterior arch or the posterior arch may not be completely fused with the occiput. Non-segmentation may have occurred only on one side.

Neurological signs are not present in all cases visualized by the roentgen ray. In congenital cases, for some unknown reason, the first symptoms are likely to appear as

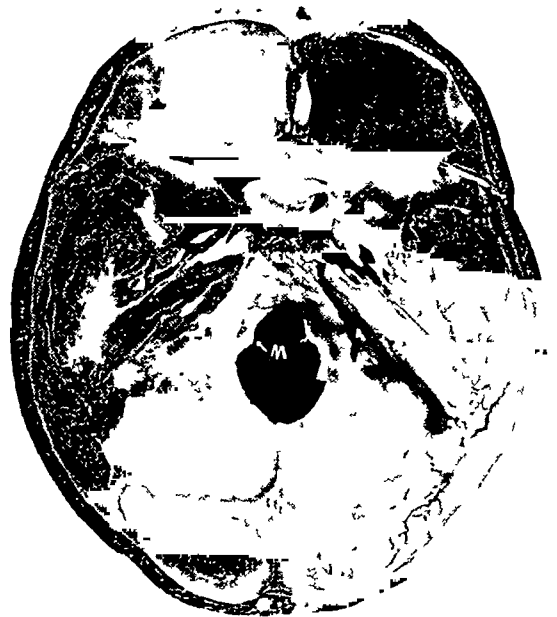


FIG. 14. Same specimen. Distortion of the foramen magnum by anterolateral bony masses (M). Foramen shaped like a bicycle seat resembles that of Case I. Floor of cerebellar fossa elevated on right side. Entire right side of skull smaller than left side. Asymmetry is a prominent feature in congenital cases.

late as the second or third decade but may be progressive and even fatal. They are caused by: (1) constriction of the foramen with resultant pressure upon nervous structures; (2) adhesions; (3) ischemia from interference with blood supply; (4) interference with the dynamics of the cerebrospinal fluid between the ventricles and subarachnoid spaces causing hydrocephalus, and (5) increased pressure within the cerebellar fossa from basilar impression or invagination.

In the congenital cases basilar invagination may be minimal or entirely lacking and the symptoms may result largely from deformity of the foramen magnum.



FIG. 15. Specimen No. 2. Block vertebra comprising the first four cervical segments with complete atlanto-occipital fusion. The occiput is tipped toward the left side. On the right side elements of the atlanto-occipital and atlanto-axial articulations may still be identified but these joints are both ankylosed. There is senile degeneration of the fourth, fifth and sixth discs and the sixth disc is ankylosed on left side.

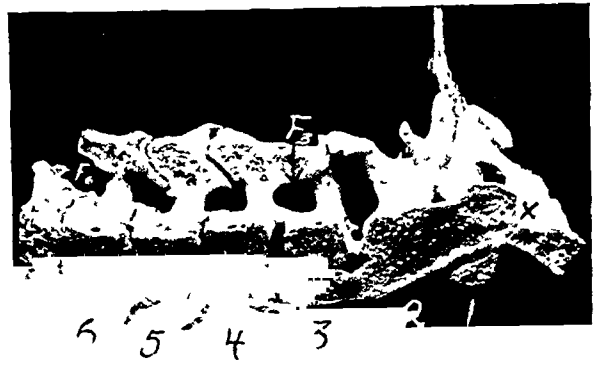


FIG. 16. Sagittal section (segments numbered). The odontoid is ankylosed to the occiput and arch of the atlas and projects backward into the spinal canal (X). The second and third disc spaces contained fibrous tissue but not typical cartilaginous disc material. The fourth, fifth and sixth discs show the typical changes of senile degeneration. The second foramen is distorted by being continuous with the disc space but the third (F_3) shows the smooth rounded lumen characteristic of congenital block vertebra. The disc margins, in congenital non-segmentation, do not project out beyond the plane of the vertebral bodies as they do in cases of traumatic or senile fusion. The fourth, fifth and part of the sixth (F_6) foramina show distortion of the senile or degenerative type. I believe this to be a specimen of congenital atlanto-occipital fusion with block vertebra. It is a good example of the asymmetry which characterizes so many of these cases.

In the acquired cases secondary to a softening of the base of the skull, the invagination of the occiput upward into the posterior fossa acts as a piston. The tentorium being fixed, pressure is exerted upon the cerebellum. Brain substance may be forced to herniate downward into the spinal canal somewhat as noted in the Arnold-Chiari syndrome. In these secondary cases as the skull base widens there may be traction upon the posterior five or six pairs of cranial nerves.

In addition to the increased intracranial pressure and hydrocephalus, the neurological symptoms are those of irritability or paralysis involving the cranial or cervical nerves and the spinal cord tracts.

Roentgenographic Examination. Good stereoscopic roentgenograms are much superior to planigrams. A lateral survey film

with the head at full limit of forward flexion should detect nearly all cases. Normally the posterior arch of the atlas separates widely from the occiput when the head is nodded forward.

The foramen magnum may be visualized by either the vertex-occiput or occiput-vertex projections, but there is some distortion. These patients are likely to have an increased cervical lordosis and good stereoscopic base-vertex views with the head in extreme dorsal extension show the foramen magnum without distortion. Roentgenograms of the finest technical quality are necessary in this position and the underlying second cervical neural arch must not be mistaken for the foramen.

The odontoid, visualized within the foramen magnum, may be studied through the open mouth with the neck dorsally flexed, or better still according to the method of Kasabach (Fig. 3). For this, the patient lies supine, sagittal plane of the skull 45° to the horizontal, the central ray directed 10 or 15° toward the feet and centered in the middle of the uppermost zygomatic arch.

Opaque medium in the spinal canal may be useful to visualize obstruction at the foramen magnum.

While the clivus and even the petrous pyramids may be displaced upward, the basilar angle (root of nose—sella turcica— anterior margin of foramen magnum) may not even reach the normal maximum value of 150° recorded by anthropologists (140° in Case v). In Figure 11, a case of advanced acquired basilar impression secondary to Paget's disease, the basilar angle, measured in the midline to anterior margin of the foramen magnum, is about 110° . If the highest point of the invagination is used as the posterior side of the angle, it becomes 135° . This is still within the normal anthropological limit. As suggested by Craig, the term platybasia should be discarded in favor of basilar impression.

In the anteroposterior view (made with the central ray aligned with the tip of the mastoid and the zygoma) the planes of the atlanto-occipital and the atlanto-axial ar-

ticulariations may be seen when present. In patients with basilar impression the elevated basilar condyles and foramen magnum appear as a double sine curve on the anteroposterior view. That is, the lateral portions of the posterior fossa curve downward while the medial parts, adjacent to the funnel-like foramen, curve upward on each side.

Easier to visualize is the sine curve as seen from the lateral direction. Here, in place of the normal downward curve of the entire occiput, only the posterior part of the cerebellar fossa curves downward while that portion about the foramen has become elevated and curves upward (Fig. 12).

A suboccipital decompression operation with upper cervical laminectomy and opening of the dura is indicated in an attempt to arrest the progressive compression and destruction of nerve tissue. Of course, restoration of normal bone relations or destroyed nervous tissue is impossible. Fusion should be done if the atlas was dislocated. The congenital should be differentiated from the secondary cases as the latter are held to be a poorer operative risk. Respiratory embarrassment may be a troublesome complication.

CONCLUSIONS

Certain congenital and acquired anomalies occurring at the foramen magnum may cause neurological symptoms.

Congenital deformities such as atlanto-occipital fusion, occipital vertebra and ossiculum terminale usually cause symptoms by constriction of the foramen magnum.

Basilar impression, an acquired distortion secondary to softening of the base of the skull, causes development of pressure within the cerebellar fossa by invagination of that part.

Early operation offers promise of arresting the progress of the condition, although restoration of normal relationships is impossible.

Because one of these conditions at the foramen magnum may be confused with

multiple sclerosis, syringomyelia or other degenerative spinal cord disease, a survey film will be found desirable.

The survey film is a lateral view of the cervical spine with the head in anterior flexion. If the arch of the atlas is not fused to the occiput, it will separate from that bone in this position.

A similar lateral survey film should be taken in all cases of torticollis or asymmetry of the head and neck.

If a congenital anomaly of this type is discovered in a young child not yet showing symptoms, his parents should be acquainted with the possibilities and remain alert for the first appearance of neurological signs. These may not appear until the second or third decade.*

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REFERENCES

1. BÉZI, I. Assimilation of atlas and compression of medulla. *Arch. Path.*, 1931, 12, 333-357.
2. BYSTROW, A. Assimilation des Atlas und Manifestation des Proatlans. *Ztschr. f. d. ges. Anat.* (Abt. 1), 1931, 95, 210-242.
3. CHAMBERLAIN, W. E. Basilar impression (platybasia). *Yale J. Biol. & Med.*, 1939, 11, 487-496.
4. CRAIG, W. M., WALSH, M. N., and CAMP, J. D. Basilar invagination of skull—so called platybasia. *Surg., Gynec. & Obst.*, 1942, 74, 751-754.
5. CUNNINGHAM, D. J. Connection of os odontoid with the body of the axis vertebra. *J. Anat. & Physiol.*, 1886, 20, 238.
6. CUSTIS, D. L., and VERBRUGGHEN, A. Basilar impression resembling cerebellar tumor. *Arch. Neurol. & Psychiat.*, 1944, 52, 412-415.
7. DAVIDOFF, L. M. Discussion of paper by Gustafson and Oldberg.¹⁸
8. DWIGHT, T. Description of human spines showing numerical variation in the Warren Museum of the Harvard Medical School. *Memoirs Boston Soc. Nat. Hist.*, 1901, 5, 237.
9. DWIGHT, T. Diagnosis of anatomical anomalies causing malposition of head and distortion of the face. *J. Med. Research*, 1904, 12, 17.

10. EBENIUS, B. Roentgen appearance in four cases of basilar impression. *Acta radiol.*, 1934, 15, 652-656.
11. EDITORIAL. Basilar impression (platybasia). *AM. J. ROENTGENOL. & RAD. THERAPY*, 1939, 42, 443-444.
12. FAY, T. Discussion of paper by Wycis.⁵²
13. FURST, W., and OSTRUM, H. W. Platybasia, Klippel-Feil syndrome and Sprengel's deformity. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1942, 47, 588-590.
14. GIACOMINI. Os odontoideum. *Gior. d. r. Accad. di med.*, 1886.
15. GLADSTONE, J., and ERICKSON-POWELL, W. Manifestation of occipital vertebra and fusion of atlas with occipital bone. *J. Anat. & Physiol.*, 1914-1915, 49, 190.
16. GLADSTONE, R. J., and WAKELEY, C. P. G. Variations of occipito-atlantal joint in relation to metameric structure of cranio-vertebral region. *J. Anat.*, 1924-1925, 59, 195.
17. GREEN, H. L. Unusual case of atlanto-occipital fusion. *J. Anat.*, 1930-1931, 65, 140-144.
18. GUSTAFSON, W. A., and OLDBERG, E. Neurologic significance of platybasia. *Arch. Neurol. & Psychiat.*, 1940, 44, 1184-1198.
19. HADLEY, L. A. Platybasia and occipital vertebra causing foramen magnum encroachment and resulting neurologic symptoms. *New York State J. Med.*, 1944, 44, 2355-2357.
20. HARROWER, G. Variations in region of foramen magnum. *J. Anat.*, 1922-1923, 57, 178.
21. HAYEK, H. Quoted by Bystrow.²
22. HAYEK, H. Quoted by Bézi.¹
23. KAHN, E. A., and YGLESIAS, L. Progressive atlanto-axial dislocation. *J.A.M.A.*, 1935, 105, 348-352.
24. KASABACH, H. H. Roentgenographic method for study of second cervical vertebra. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1939, 42, 782-785.
25. LANIER, R. R., JR. Anomalous cervico-occipital skeleton in man. *Anat. Rec.*, 1939, 73, 189-207.
26. LAUBE, P. J., and TURNER, O. A. Platybasia. *Yale J. Biol. & Med.*, 1941, 13, 643-648.
27. LAWRENCE W. S., and ANDERSON, W. D. Rare developmental abnormality of atlas. *Radiology*, 1937, 28, 55-57.
28. LE DOUBLE, A. F. *Traité des variations des os du crâne de l'homme*. Vigot Frères, Paris, 1903.
29. LICHTENSTEIN, B. W. Cervical syringomyelia and syringomyelia-like states associated with Arnold-Chiari deformity and platybasia. *Arch. Neurol. & Psychiat.*, 1943, 49, 881-894.
30. LICHTENSTEIN, B. W. Distant neuroanatomic complications of spina bifida (spinal dysraphism). *Arch. Neurol. & Psychiat.*, 1942, 47, 195-214.

* Since this paper was written, a patient has been examined showing atlanto-occipital fusion on the left side but not on the right. There is some asymmetry in the shape of the skull. There are no pertinent neurological symptoms, no deformity of the foramen magnum and no basilar impression. There is, however, a block vertebra showing non-segmentation of the second, third and fourth cervical elements.

31. LINDGREN, E. Roentgenological views on basilar impression. *Acta radiol.*, 1941, 22, 297-302.
32. LIST, C. F. Neurological syndromes accompanying developmental anomalies of occipital bone, atlas and axis. *Arch. Neurol. & Psychiat.*, 1941, 45, 577-616.
33. LITTLE, S. C., and PASCUCCI, L. M. Basilar impression and associated deformities—case report. *New York State J. Med.*, 1945, 45, 638-642.
34. MACALISTER, A. Notes on development and variations of the atlas. *J. Anat. & Physiol.*, 1892, 27, 519-542.
35. MOTWANI, R. C. Some rare abnormalities of bones in Anatomy Museum of Grant Medical College, Bombay. *J. Anat.*, 1936, 71, 131-133.
36. NAYAK, U. V. Case of abnormal atlas and axis vertebra. *J. Anat.*, 1931, 65, 399-400.
37. OETTEKING, B. On the morphological significance of certain cranio-vertebral variations. *Anat. Rec.*, 1923, 25, 339.
38. PEYTON, W. T., and PETERSON, H. O. Congenital deformities in region of foramen magnum; basilar impression. *Radiology*, 1942, 38, 131-144.
39. PLAUT, H. F. Fracture of atlas or developmental abnormality? *Radiology*, 1937, 29, 227-231.
40. RAU, R. K., and SIVASUBRAHMANYAM, D. Anomalous atlanto-occiput. *J. Anat.*, 1933, 67, 622-623.
41. RAY, B. S. Platybasia with involvement of central nervous system. *Ann. Surg.*, 1942, 116, 231-250.
42. ROBERTS, S. M. Congenital absence of odontoid process resulting in dislocation of atlas on the axis. *J. Bone & Joint Surg.*, 1933, 15, 988-989.
43. SAUNDERS, W. W. Basilar impression; position of the normal odontoid. *Radiology*, 1943, 41, 589-590.
44. SCANNELL, R. C. Congenital absence of odontoid process. *J. Bone & Joint Surg.*, 1945, 27, 714-715.
45. SCHIFFNER, C. T. Ueber die Architectur des Schädelgrundes in der Norm und bei Assimilation des Atlas. *Virchow's Arch. f. path. Anat.*, 1878, 74, 320.
46. SCHÜLLER, A. Diagnosis of "basilar impression." *Radiology*, 1940, 34, 214-216.
47. SOLGER. Ueber abnorme verschmelzung knorpelig Skelettneile beim Foetus. *Centralbl. f. allg. Path. u. path. Anat.*, 1890, 1. Quoted by Dwight.
48. STEVENS, R. H. Platybasia; report of case treated surgically with improvement. *Surgery*, 1942, 12, 943-951.
49. SYMONDS, C. P., MEADOWS, S. P., and TAYLOR, J. Compression of spinal cord in neighbourhood of foramen magnum, with note on surgical approach. *Brain*, 1937, 60, 52-84.
50. WADE, L. J. Pseudo-platybasia: Rupture of transverse ligament of the axis with displacement of odontoid process and compression of cervical cord. *J. Bone & Joint Surg.*, 1941, 23, 37-43.
51. WEILER, H. G. Congenital absence of odontoid process of the axis with atlanto-axial dislocation. *J. Bone & Joint Surg.*, 1942, 24, 161-165.
52. WYCIS, H. T. Platybasia secondary to osteitis deformans—successful surgical result. *Arch. Neurol. & Psychiat.*, 1945, 54, 68.



IMPORTANT SEQUELAE AND COMPLICATIONS OF HEMOTHORAX RESULTING FROM PENETRATING WOUNDS OF THE PLEURAL CAVITY*

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IN CONSIDERING the management of thoracic injuries, one clear-cut lesson of World War II is that prompt and repeated aspiration of traumatic hemothorax is the immediate treatment of choice. The presence of free blood in the pleural cavity is much less important as a hemostatic agent than is its prophylactic removal to obviate the formation of fibrinous pleuritis. In each case, thoracentesis should be performed frequently until no significant fluid remains in the pleural cavity.^{1,2,3,4}

Prognosis depends, to a great extent, upon spontaneous internal hemostasis. Satisfactory resolution of a hemothorax may be obtained by simple thoracentesis if hemorrhage ceases promptly. Successful clearing of the pleural cavity may be attained even in slow, prolonged bleeding if simultaneous adequate aspiration of the blood is practiced. However, in the presence of continued slow hemorrhage, if the blood begins to organize before it can be evacuated successfully, important complications are apt to develop. Cessation of bleeding may be recognized by physical signs and on roentgenograms of the chest. However, even these diagnostic channels may be misleading for the quantity of fluid may increase, decrease, or remain unchanged and yet its quality become serosanguineous. This change from blood to serosanguineous fluid also indicates cessation of hemorrhage and can be ascertained only by aspiration.

Should the organized pleural cavity hemorrhage leave a residual fibrinous pleuritis which is not extensive and not a factor contributing to irreversible pneumothorax, this pleuritis may be resorbed completely.

Penetrating wounds of the pleural cavity may or may not produce an associated demonstrable internal or external pneumothorax. Through and through penetration of the lung by a high velocity missile may result in no demonstrable pneumothorax. If a hemopneumothorax occurs, re-expansion of the lung and removal of the blood in the pleural cavity may be attained by simple thoracentesis. However, if an early tenacious fibrinous pleuritis forms, expansion of the completely or partially collapsed lung is inhibited. The result is often a semiloculated hemopneumothorax with a dead space which can be obliterated only by radical surgical decortication of the thick, tough, leathery fibrinous pleuritis.

The following cases are illustrative of some of the sequelae and complications of free blood in the pleural cavity:

REPORT OF CASES

CASE I. R.S. Patient was admitted on October 10, 1946, with a penetrating gunshot wound of the right chest. The wound of entrance was in the eighth costal interspace directly below the nipple. Signs and symptoms indicated penetration of the right diaphragm and the liver by the bullet; and roentgenograms revealed fractures of the neural arch of the twelfth thoracic vertebra. Neurological examination demonstrated complete paralysis and anesthesia of the lower extremities, commensurate with spinal cord damage at the level of the twelfth dorsal vertebra. Roentgenograms of the chest made with the patient supine indicated a considerable right hemothorax without demonstrable pneumothorax.

Eleven hundred cubic centimeters of blood were removed from the right pleural space on October 10, 1,000 cc. aspirated on October 11,

* From the Radiologic Department of the 97th General Hospital.

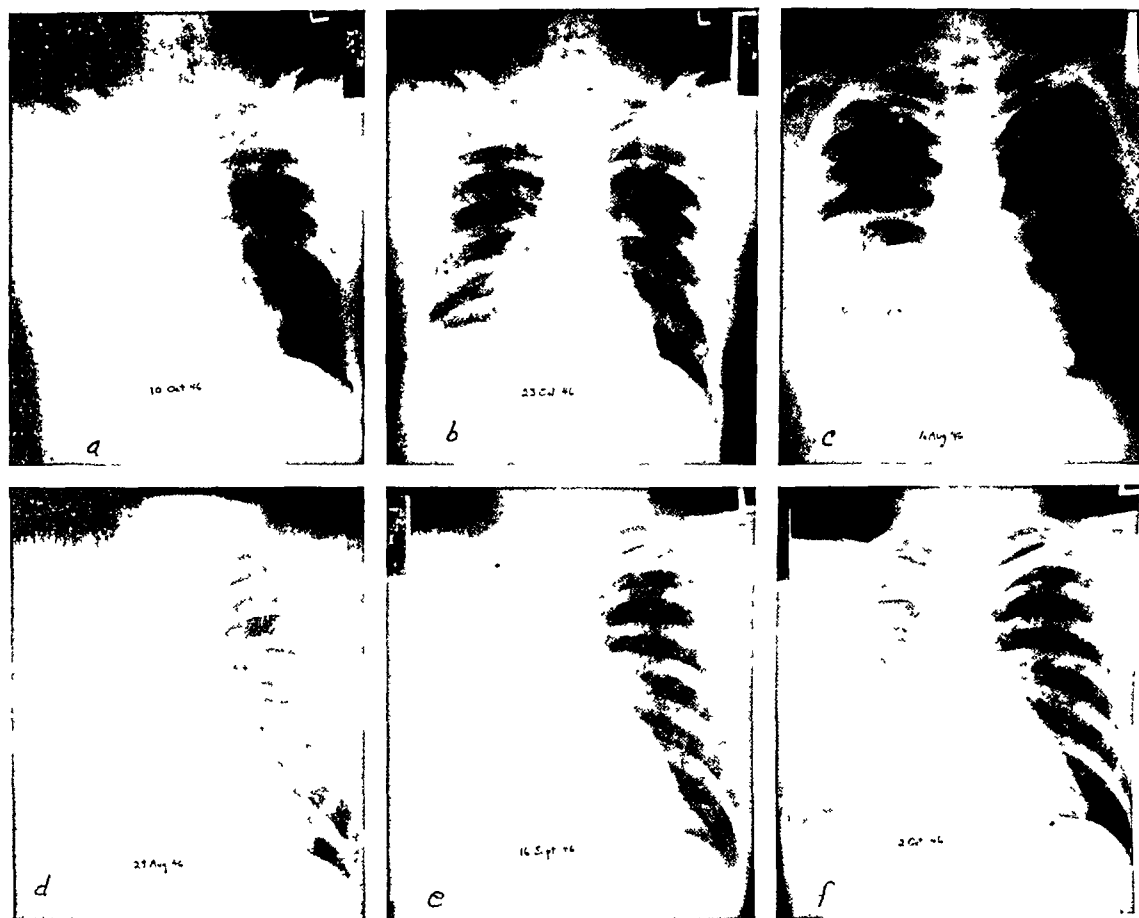


FIG. 1. Case I. (a) Gunshot wound of right lower chest and abdomen. Roentgenogram made with patient supine five hours after injury demonstrates extensive right hemothorax through which moderately well aerated lung tissue is visible. Twenty-five hundred cubic centimeters of blood aspirated from right chest in forty-eight hours. (b) Two weeks later the lung fields are clear and only very faint residual pleuritis indicates site of previous hemothorax.

Case II. (c) Multiple stab wounds of right chest. Film shortly after injury reveals moderate hemothorax without pneumothorax. No thoracentesis performed. (d) Two weeks later a pronounced hemothorax is demonstrable and, because of the length of time during which the blood has been allowed to accumulate in the pleural cavity, associated fibrinous pleuritis was suspected. About 700 cc. of blood were aspirated in the ensuing days. (e) Dense fibrinous pleuritis obscuring detail of right chest. No appreciable free pleural fluid and no complicating pneumothorax. (f) Remarkable resorption of the dense organized pleuritis. Respiratory exchange good. No complaints.

and 450 cc. on October 12. No further thoracenteses were performed. Film on October 23 showed an almost clear lung on the right and an insignificant residual thickened pleura at the right base. Patient evacuated to Zone of Interior because of spinal cord lesion.

Comment. This history demonstrates that prompt aspiration associated with spontaneous hemostasis and the absence of pneumothorax may result in a fully expanded well aerated lung without late ad-

hesive fibrinous pleuritis. This is the simple uncomplicated ideal (Fig. 1).

CASE II. F.C. On July 4, 1946, patient was admitted to another hospital with a penetrating gunshot wound of the left chest anteriorly just below the mid-portion of the clavicle. Roentgenogram at that time revealed left hemothorax with questionable pneumothorax and also an incomplete fracture of the posterior portion of the left fourth rib. A second film the same day showed pronounced increase in the degree of

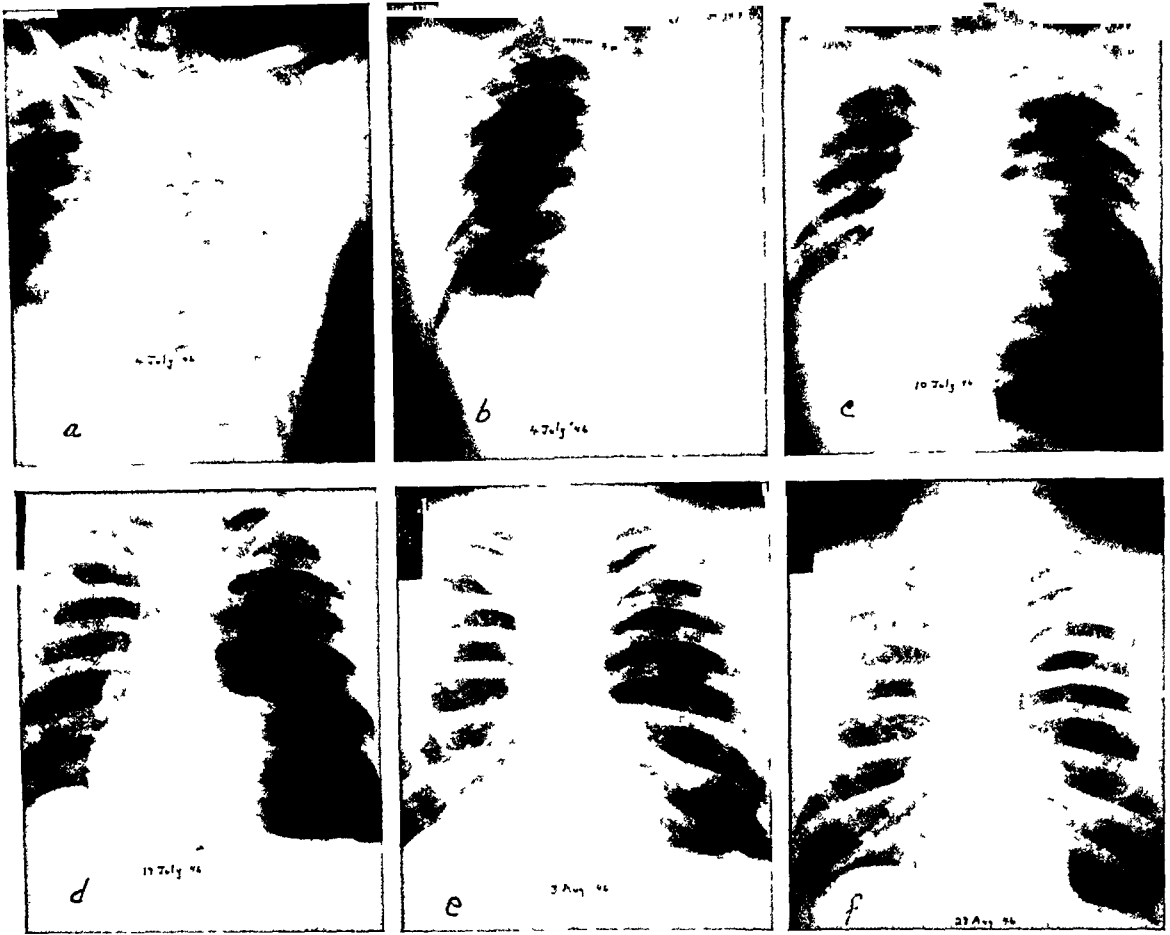


FIG. 2. Case III. (a) Gunshot wound of left chest. Early hemothorax and questionable pneumothorax. Slight mediastinal shift to the right. (b) Film made four hours later shows pronounced increase in left hemothorax. (c) After removal of 600 cc. of blood there is an extensive left pneumothorax, but very little blood in the left pleural cavity. (d) Low grade tension pneumothorax with only slight amount of free pleural fluid. Note mediastinal shift to the right. (e) and (f) Two phases of the uncomplicated re-expansion of the left lung. On the latest film insignificant basal pleuritis localizes the previous hemothorax. Pulmonary expansion is nearly complete.

hemothorax. The patient remained at this hospital until July 16, during which time three thoracenteses were performed. The first recovered 300 cc. of blood, the second 270 cc., and the third was reported a "dry" tap. By July 10, a definite pneumothorax was demonstrable. On admission to the 97th General Hospital, a tension pneumothorax was recognized on the roentgenogram of July 17. This was relieved. Subsequent films revealed progressive expansion of the left lung with only slight residual fibrinous pleuritis in the base. Patient discharged to duty early in September, 1946.

Comment. This case shows that pneumothorax is no serious complication provided

whatever blood is present in the pleural cavity is removed promptly (Fig. 1).

CASE III. W.C. Patient was stabbed three times in the right chest and admitted to another hospital on August 10, 1946. Roentgenogram on August 16 showed moderate hemothorax without demonstrable pneumothorax. Aspiration of the right chest on August 27 yielded 185 cc. of blood. On August 29 an extensive right hemothorax was present on the film, and 450 cc. was aspirated two days later and also a "small amount" on September 11. Patient was admitted to the 97th General Hospital on September 16, at which time the roentgenogram revealed no appreciable free fluid in

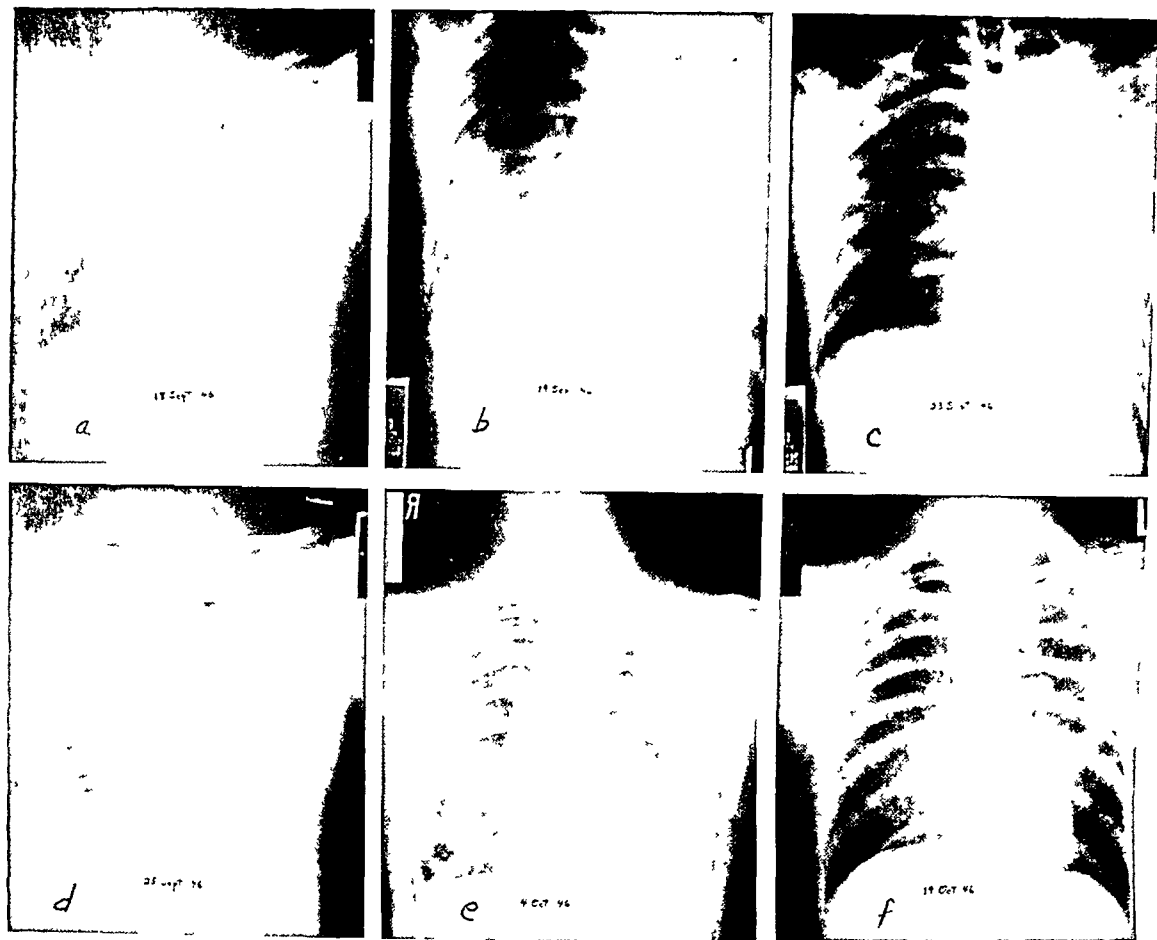


FIG. 3. Case IV. (a) Crushing injury to chest with left hemothorax and multiple rib fractures. Film made two hours after injury. (b) Two days later the left hemothorax is extensive and the right lower lung field is the seat of interstitial pulmonary hemorrhage, the result of small vessel rupture secondary to the blow to the thorax. In the following twenty-four hours, 1,600 cc. of blood aspirated. (c) Up to this date the character of the fluid in the left pleural cavity was bloody and it reaccumulated after each tap. At this time the fluid became serosanguineous. Note that the right-sided interstitial hemorrhage has been resorbed. Such a rapid disappearance of this condition is the usual occurrence. (d) Beginning resorption of residual fluid and of secondary fibrinous pleuritis in the left chest. (e) and (f) Two phases in the eventual complete disappearance of the densely organized hemothorax. The last film demonstrates a clear pleural space.

the right hemithorax. However, a densely organized and probably fibrinous pleuritis was present all along the right lateral chest wall. No thoracentesis was performed here, and gradually the pleural thickening was resorbed so that by October 2 this was greatly decreased and there was good respiratory exchange on the right. Patient was discharged to duty at this time.

Comment. This record illustrates that moderate but incomplete removal of an extensive hemothorax not complicated by pneumothorax may result in a certain amount of fibrinous pleuritis. However,

since the lung is expanded there is no opportunity for extensive adhesions to form and thereby limit the capacity of respiratory exchange. This fibrinous pleuritis may be resorbed slowly and without significant residues (Fig. 2).

CASE IV. E.B. This patient was in a jeep accident on September 17, 1946, and sustained a crushing injury to the left chest. A roentgenogram on September 17 revealed fractures of the posterior portions of the second, third, fourth, sixth, ninth, and tenth left ribs and the anterior portions of the second, fourth, and sixth left

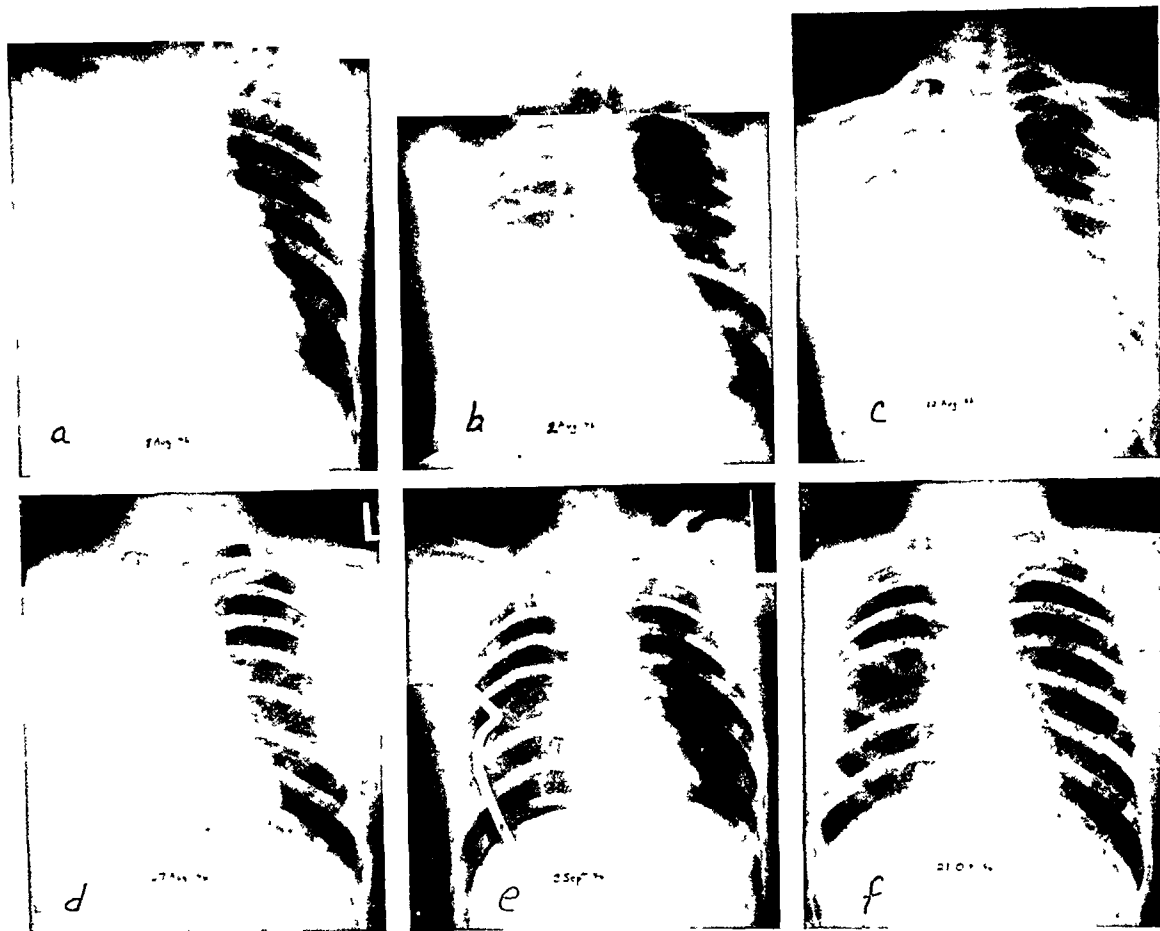


FIG. 4. Case v. (a) Gunshot wound of the right chest with secondary extensive hemothorax. (b) Reduction in hemothorax following thoracentesis (unknown amount of blood removed). No pneumothorax demonstrable yet. (c) In spite of repeated small thoracenteses blood reaccumulated rapidly. Two weeks after injury, organization of the blood has formed considerable fibrinous pleuritis. This inhibits pulmonary expansion and produces a semiloculated hemopneumothorax as evidenced by the multiple air-and-fluid levels. (d) The fibrinous pleuritis has increased and bleeding continues. At this time 800 cc. of bloody fluid were removed. (e) Film made immediately after surgical decortication of $\frac{1}{4}$ inch thick fibrinous pleuritis. Right lung is free and expanded approximately 65 per cent. Suction catheter in place. (f) Seven weeks later lung is fully expanded and only very faint residual peripheral pleuritis persists. Patient had no complaints.

ribs. Repeated films on this date revealed that the left pleural cavity was filling with blood rapidly. By September 19 a dense left hemothorax was present as well as evidence of parenchymal lung tissue hemorrhage in the lower half of the right lung. Left thoracentesis of 800 cc. of blood was performed, but blood reaccumulated and 800 cc. were again aspirated on September 21 and 23. On this last date the character of the fluid had changed to serosanguineous, indicating that active hemorrhage had ceased. In the following weeks the left hemithorax became progressively clearer without additional taps and by October 19 all evidence of hemothorax and pleural thickening

had disappeared. Patient was discharged to duty on October 20.

Comment. This case demonstrates the principle of repeated thoracenteses as long as physical and roentgen examination reveals reaccumulation of pleural fluid. Change in the character of the fluid is an important prognostic sign. A good result is obtainable despite prolonged bleeding (Fig. 3).

CASE V. E.D. Patient was shot on July 29, 1946, the bullet entering the second right intercostal space. Roentgenograms at another hos-



FIG. 5. Case VI. (a) Film made nine days after penetrating gunshot wound of left chest; 1,860 cc. of blood had already been removed. Hemopneumothorax present. (b) Extent of the hemopneumothorax has increased in the four day interval despite removal of an additional 1,365 cc. of blood. (c) Roentgenogram one month later demonstrates relatively static hemopneumothorax. Expansion of the lung is inhibited by the formation of a heavy fibrinous pleuritis. Approximately 3,000 cc. of old blood and serosanguineous fluid were removed from the left pleural cavity between June 30 and September 30. Multiple puncture sites were necessary and the aspirating needle frequently became clogged with fibrin. (d) Film made immediately after extensive decortication of $\frac{1}{4}$ inch thick fibrinous pleuritis. Before closure of the thoracic cage the left lung seemed expandable and completely free. However, film shows almost full collapse. Total collapse of the left lung persisted postoperatively and small amounts of free blood continued to collect in the pleural cavity

pital made before and after repeated small aspirations of the right pleural cavity showed that bleeding was not controlled and that blood reaccumulated after each tap. By the time the patient was admitted to the 97th General Hospital an advanced semiloculated hemopneumothorax was present. Between August 12 and 27 the right pleural cavity continued to fill slowly with bloody fluid and 800 cc. were removed on this last date. To remove this fluid it was now necessary to perform multiple punctures due to the loculation caused by extensive fibrinous pleuritis.

On September 3 the right chest was exposed at operation and a dense $\frac{1}{4}$ inch thick fibrinous pleuritis was seen binding the lung down to the mediastinum in many places. This was decorticated very thoroughly and the lung re-expanded by positive pressure exerted by a closed anesthesia system. A suction catheter was placed in the right pleural cavity and an immediate postoperative roentgenogram showed the lung to be about 60 per cent expanded. Complete expansion of the lung was demonstrated by films at daily intervals at which time the gradual resorption of the peripherally located residual postoperative pleural thickening was noted also. By October 21 expansion was complete, but there was noted behind the proximal portion of the right clavicle a convexly bordered density which was thought to represent a residual area of thickened pleura or small unresolved loculated pleural effusion. Patient was evacuated to Zone of Interior early in November.

Comment. Case v demonstrates that insufficient tapping in the presence of a hemopneumothorax allows a fibrinous pleuritis to form. This binds the lung to the mediastinum. Successful decortication of the lung with good postoperative hemostasis results

in a healing pattern similar to Case i (Fig. 4).

CASE VI. W.T. On June 17, 1946, patient suffered a penetrating gunshot wound of the left chest, the bullet entering at the level of the third rib to the left of the sternum and leaving the thorax at the vertebral border of the left scapula. During the first nine days' hospitalization at another institution, 1,860 cc. of blood were removed from the left chest. On June 27, 1,365 cc. of dark bloody fluid were aspirated, and on July 1 and 3, 730 cc. and 400 cc. were removed. The patient then began to run a spiking fever which was controlled by penicillin. On July 6 and 9, 380 cc. and 260 cc. were withdrawn. By this time a definite hemopneumothorax had been demonstrated roentgenographically, and the patient was transferred to the 97th General Hospital. On July 16, 200 cc. of old blood were removed and the aspirating needle was discovered clogged with fibrin. Slight temperature elevation persisted despite penicillin. Through the months of August and September repeated attempts to tap the left pleural cavity recovered only 100-200 cc. of bloody fluid each time. Roentgenograms demonstrated semiloculation of the pleural fluid and a partially collapsed left lung, thoroughly enmeshed in a dense fibrinous pleuritis.

On September 30 the left hemithorax was opened and a fibrinous pleuritis $\frac{1}{4}$ inch thick was observed compressing the lung against the mediastinum. This was removed by careful dissection and, under forced intrabronchial positive pressure, the lung appeared expansible. A suction catheter was inserted into the left pleural cavity and the wound otherwise closed. An immediate postoperative roentgenogram failed to reveal the expected expansion of the left lung. On October 1, 500 cc. of fresh blood were removed from the left chest and it was

despite repeated aspirations. (e) Condition of left hemothorax before application of strong negative pressure. (f) Partial expansion of left lung during the application of strong negative pressure to the left pleural cavity. (g) Four hours after the release of the negative pressure complete collapse again is demonstrable. At this time it was believed that re-expansion was inhibited by an upper lobe bronchopleural fistula and the reaccumulation of dense fibrinous pleuritis. Thoracotomy was performed again. The suspected upper lobe bronchopleural fistula was discovered and closed. The reaccumulated dense fibrinous pleuritis was removed again. (h) Film on the fifth postoperative day demonstrates partial collapse of the left lung. Suction catheter in place. (i) Three weeks after operation the upper two-thirds of the left lung is expanded completely, while expansion of the lower portions continues to be inhibited somewhat by the pleuritis which formed rapidly. Residual lipiodol in the lower lobe bronchi delineates the degree of expansion. It is believed that much of this pleuritis will be resorbed eventually. Patient had no serious complaints.

apparent that renewed intrapleural bleeding had occurred. On October 4 another 500 cc. were removed and the medical officer observed a moderate amount of air in the aspirating syringe. Repeated thoracenteses in the ensuing days recovered only 75-100 cc. of fluid. It was also noted at each tap that, upon initial application of suction, a positive intrathoracic pressure was encountered which promptly became a negative one. Continuous suction was applied for several days up to the limit of tolerance of the patient but without benefit. Lipiodol was instilled into the left main stem bronchus under fluoroscopic guidance and roentgenograms revealed patency of the main bronchial divisions and their secondary branches. The peripheral fields of the upper lobe were not filled and no opaque medium was seen free in the pleural cavity. Finally it was agreed that failure of re-expansion was caused by the combined presence of a bronchopleural fistula high in the left upper lobe and reformation of dense fibrinous pleuritis due to bleeding after operation.

On November 5 the left chest was exposed again and both wound lesions were verified and eliminated. An immediate postoperative film showed approximately 40 per cent expansion and twenty-four hours later under continual suction the lung exhibited 60-70 per cent of its normal volume. The suction catheter was removed and the upper lobe expanded in a few days. However, the lower lobe failed to exhibit complete expansion due to limitation by an elevated and partially fixed left diaphragm and by a rapid recurrence of peripheral pleural thickening. Four weeks later, a roentgenogram showed little change but respiratory exchange was good and there were no subjective symptoms.

Comment. Case VI shows that despite repeated removals of large amounts of blood its reaccumulation in the pleural cavity

may be so persistent that all conservative attempts fail to obviate the formation of extensive adhesive fibrinous pleuritis associated with pneumothorax. Delay in decortication is valueless. Following initial decortication failure of re-expansion may be caused by a secondary bronchopleural fistula, reaccumulation of pleural blood postoperatively, or formation of a mucous plug in a large bronchus. Removal of these complications is necessary before satisfactory pulmonary expansion can be obtained (Fig. 5).

SUMMARY

Six exemplary cases of penetrating wounds of the pleural cavity have been presented and discussed. Emphasis has been placed on some important sequelae and complications peculiar to the presence of free blood in the pleural cavity. Each case demonstrates a different subsequent clinical course.

The optimal handling of these cases is mentioned, and early repeated thoracentesis is stressed.

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REFERENCES

1. COLEMAN, F. P. Traumatic hemothorax. *Arch. Surg.*, 1945, 50, 14-18.
2. KENT, E. M., and TEBROCK, H. E. Posttraumatic hemothorax management. *U. S. Nav. M. Bull.*, 1945, 45, 14-21.
3. MEAKINS, J., and WALKER, T. W. After effects of wounds of the chest, and their treatment. *Canad. M. A. J.*, 1918, 8, 910.
4. MIRSKY, S. Observations on 100 cases of war chest injuries. *J. Canad. M. Serv.*, 1945, 2, 630-640.



MULTIPLE CONGENITAL MALFORMATIONS OF THE SKELETAL SYSTEM

A CASE REPORT

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THE following case presents an unusual group of congenital malformations, which separately are well known manifestations of established clinical syndromes, but which together apparently do not constitute any entity yet described. This is not surprising in view of the legion of hereditary deformities, which often makes classification difficult.

Skeletal deformities and defects are due to retarded development at a given period. In former years there was strong belief in the exogenous theory, which placed the fault on pressure from amniotic bands or from the uterus itself. This has been largely discarded in favor of the endogenous theory, in which the primary cause of the deformities is thought to be an inherent quality of the embryo itself.²

One of the most intriguing of the endogenous theories has been put forth by Engel,^{3,4} who first advanced it in the explanation of multiple malformations, but later used it to explain single deformities. He terms it "the bleb theory," and bases it on Weed's description of the area membranacea at the roof of the fourth ventricle, through which cerebrospinal fluid escapes to form the subarachnoid space. If the area membranacea remains unduly patent for some pathological reason, such as the excessive production or deficient reabsorption of the cerebrospinal fluid, or in consequence of a primary dysunion in the midline, cerebrospinal fluid escapes into the subcutis of the adjacent neck region. As the subcutaneous belbs so formed spread on the body surface, they exert a deleterious influence in their path by pressure, and

provoke an inflammatory reaction. The blebs are propelled by physical forces toward areas of least resistance, and are arrested and retained by preformed cavities and pockets such as the orbits or limb buds. This results in a great variety of deformities, depending on factors such as amount of cerebrospinal fluid produced and reabsorbed, the size, tension, and distribution of the blebs, and the stage in development when the bleb reaches the periphery.

Engel's theory was confirmed independently by Keith,⁶ who attributes these blebs to a defective placental circulation. He found the chorionic villi to be swollen, irregular, and frequently to show small cystic changes.

The characteristic belb was actually found as a "jelly-blood lump" in the neck region of the case of craniocarpal-tarsal dystrophy of Freeman and Sheldon.⁵ It disappeared in three to four days after birth, but left persistent features later recognizable on the child's face.

In many cases the congenital deformity is a recessive (and not a dominant) characteristic. The tendency to abnormal bleb formation is a hereditary abnormality, caused by one main recessive gene, but modified in its manifestations by other genes. The latter are responsible for specific features of the embryonic surface, resulting in different anomalous malformations.¹

CASE REPORT

A thirteen year old white female adolescent was admitted to the Orthopaedic Service with a hemarthrosis of the left knee following a twisting injury. Her physical appearance was so

* Service of Dr. Joseph A. Freiberg.

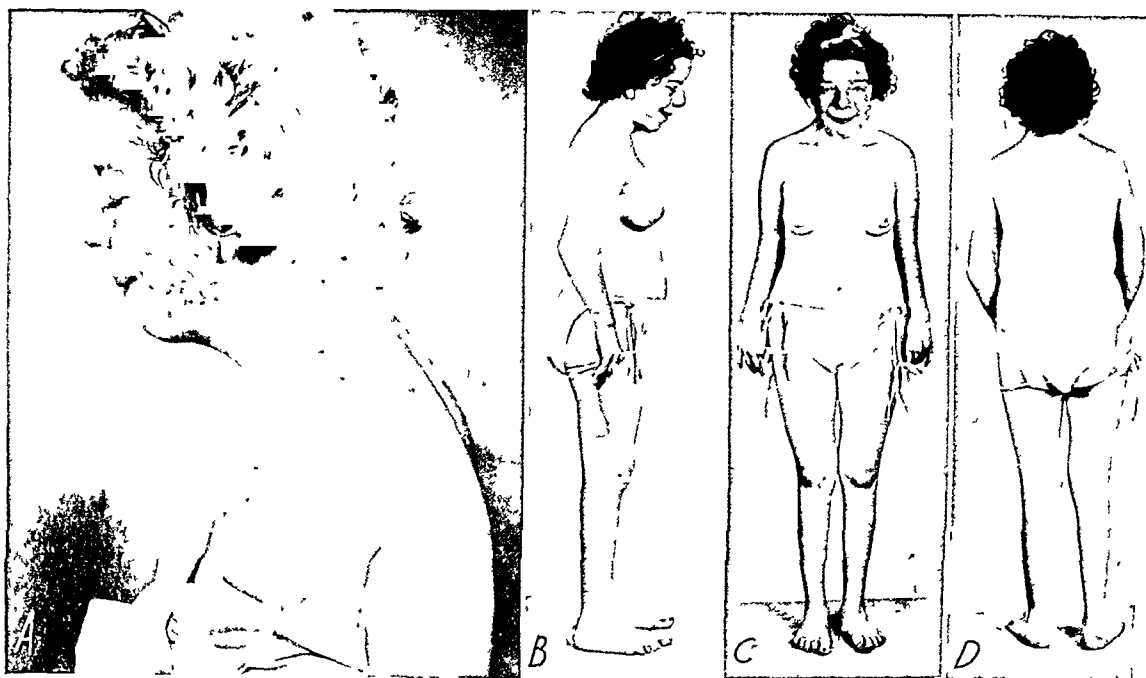


FIG. 1. *A*, note the facial expression, receding chin, and brachycephaly. *B*, there is a moderate lumbar lordosis, thickening of right elbow joint, and elongation of the great toes. *C*, brevicollis with lateral webbing is apparent. Note the widened interorbital diameter, valgus and flexed position of the elbow joints, prominence of ulnar styloid process, especially on the right, genu valgus, and pronation of feet. *D*, there is a mild rotary-lateral curvature of the dorsolumbar spine, and a broadened pelvis.

striking that further studies were made, revealing multiple congenital deformities.

Her past history revealed that she was the seventh and last child of her family. Her mother was thirty-nine years old at the time of her birth. The delivery was without incident.

Since the age of fourteen months she had been treated at other clinics with thyroid extract for developmental defects.

Her family history contained no history of familial disease or other deformities. All siblings were normal (except one, who was diagnosed a mild psychoneurotic).

On admission her temperature was 99.4° F., pulse 80 per minute, and blood pressure 112/70. Examination showed a well nourished white female adolescent who seemed somewhat mentally retarded. She stood with a mild right dorsal, left lumbar rotary lateral curvature of the spine, with a mild lumbar lordosis. Her skin was coarse, fair, dry, and markedly freckled; the scalp and hair were noticeably dry. The cranium was large with moderate frontal bossing. The facies presented an atypical mongoloid appearance with coarse features, slightly receding lower jaw and lower lip, and puffy cheeks.

The interorbital diameter was increased, suggestive of hypertelorism, and epicanthic folds were present. The eyes were large and rather expressionless. Extra-ocular movements and gross visual fields were normal. Pupils were round, regular, equal, about 3 mm. in diameter, and reacted to light and accommodation. Ophthal-



FIG. 2. Skull—moderate brachycephaly with prominent digital markings in the frontal area.



FIG. 3, *A* and *B*. Cervical spine—Klippel-Feil syndrome, with narrowing of disc between C-2 and C-3, partial fusion of the neural arches of these two vertebrae, and partial or complete fusion of the remaining cervical vertebral bodies and arches.

moscopic examination revealed no abnormalities. The nose was broad and the septum was slightly deviated to the left. The teeth were carious and in poor general condition. The tongue was pale pink, slightly coated, of normal

size, and protruded in the midline.

The neck was obviously shortened and broadened by lateral cutaneous webs and was definitely restricted in flexion and rotatory motions. The trachea was in the midline.



FIG. 4. *A*, left elbow—shallow, deformed sigmoid notch of ulna and anterior dislocation of radial head. *B*, right elbow—same as left.

The thorax was slightly asymmetrical from a dorsal kyphoscoliosis. The breasts were moderate sized and slightly pendulous. Examination of the heart and lungs was negative.

The abdominal muscles were of poor tone and the abdomen protruded slightly. There were no visceral abnormalities. The genitalia were normal for an adolescent female and there was no vaginal discharge.

The scoliosis was compensated. The shoulders

broadened, but the hips were normal. The patella was displaced superolaterally above the knee joint on both legs. There was a mild bilateral genu valgus deformity. The ankles were apparently normal. The feet were in mild pronation, but the toes were not hyperextensible or abnormal in external appearance except for an unusually long great toe on each foot.

The laboratory studies performed were essentially normal.



FIG. 5. Hands and wrists—fusion of triquetrum and lunate, navicular and greater multangular carpal bones on right. Absence of anomalies in left wrist.

were normal in range of motion and function. The elbows were visibly thickened and there was a moderate cubitus valgus present; flexion was limited to 45 degrees and extension to 150 degrees, but pronation and supination were normal. The arms and forearms seemed foreshortened. The heads of both radii were palpable and apparently dislocated anteriorly. The wrists revealed marked prominence of the ulnar styloids, but there was no radial deviation and there was a normal range of motion present. The grasp was good, but the fingers were markedly hyperextensible. The pelvis was

Blood Count:

Hemoglobin—12 gm.

Red blood cells—3,900,000

White blood cells—8,200

61% polymorphonuclears

1% eosinophils

35% lymphocytes

3% monocytes

Erythrocyte sedimentation rate—20 mm. per hour.

Blood Kahn—negative

Blood urea nitrogen—15 mg. %

Blood uric acid—3.1 mg. %

Blood sugar—97 mg. %

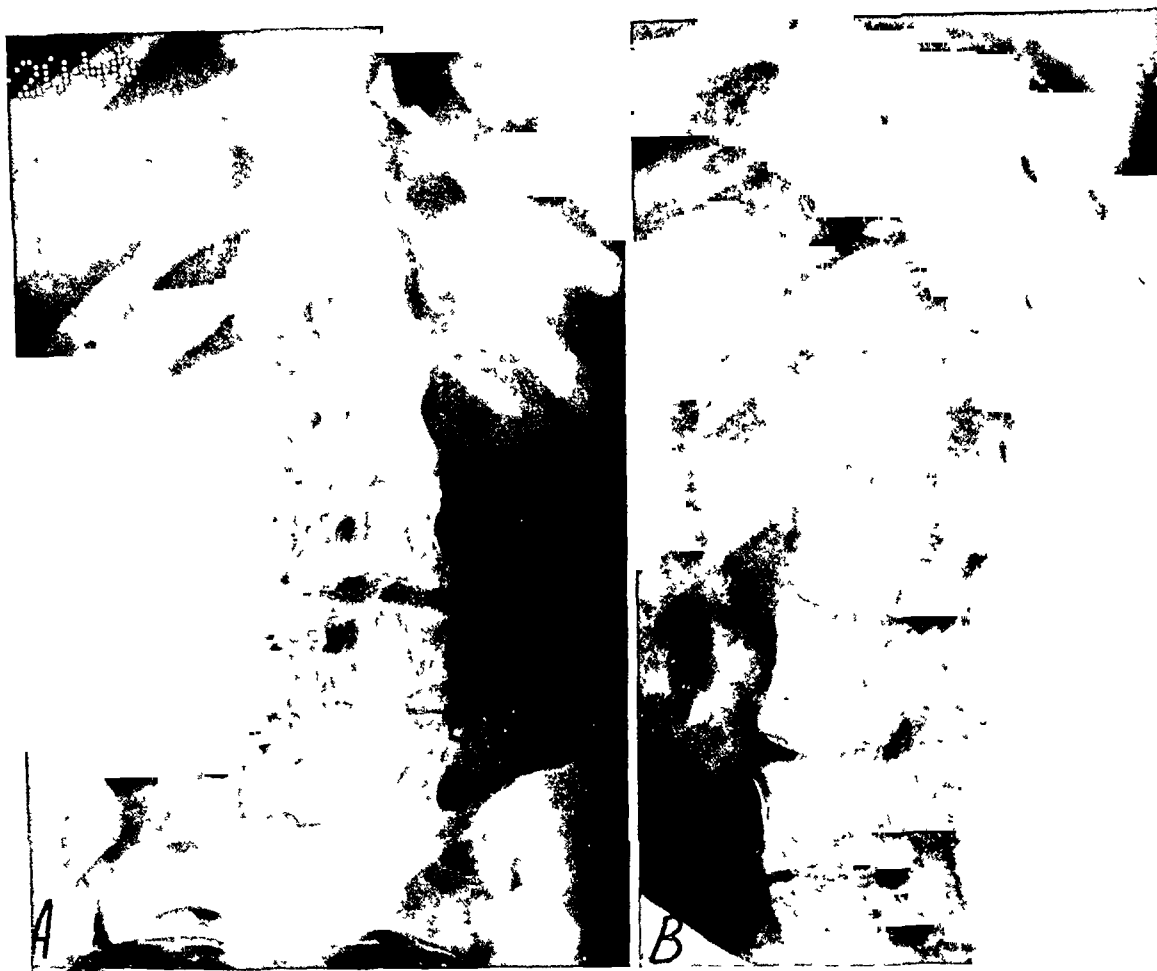


FIG. 6, *A* and *B*. Lumbar spine—left lateral scoliosis with rotation. The vertebral bodies are increased in height and shortened in their anteroposterior diameter; incomplete development of the upper lumbar epiphyses. Narrowing of the disc between L-3 and L-4, with incomplete fusion of the laminae. Incomplete transitional lumbosacral vertebra.

Serum calcium—10.6 mg. %
 Serum phosphorus—4.0 mg. %
 Serum alkaline phosphatase—4.4 Bodansky units

Urinalysis, essentially normal.

Basal metabolic rate, plus 12 per cent.

The psychometric examination revealed the child to be dull but well above the range of mental deficiency.

The deformities are illustrated by the accompanying roentgenograms and photographs.*

She is being followed in a child guidance home because of difficulties encountered when in contact with other children due to her unusual appearance.

Comment. Two outstanding skeletal aberrations are noted in this case: (1) multiple luxations, involving both patellae and both radiohumeral joints, and (2) multiple instances of congenital type fusion of small bones, involving the carpals of both wrists, cervical spine, and lumbar spine. Lesser deformities of both feet and the skull are also observed.

The anomaly of the cervical spine is identical with the Klippel-Feil type of deformity, and the patient also manifested the expressionless, mongoloid-like type of facies usually associated with that syndrome. However, because of the many other associated deformities present, this

* Appreciation is expressed to Dr Benjamin Felson, Assistant Professor, Department of Radiology, for aid in the interpretation of the roentgenograms.



FIG. 7. Left knee—superior and lateral displacement of patella.

case cannot be properly classified as belonging to that or any other known entity.

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REFERENCES

1. BONNEVIE, KRISTINE, Embryological analysis of gene manifestation in Little and Bagg's normal mouse tribe. *J. Exper. Zool.*, 1934, 67, 443.
2. COHN, I. Skeletal disturbance and anomalies. *Radiology*, 1932, 18, 592-626.
3. ENGEL, D. Etiology of multiple deformities. *Am. J. Dis. Child.*, 1940, 60, 562-579.
4. ENGEL, D. Etiology of undescended scapula and related syndromes. *J. Bone & Joint Surg.*, 1943, 25, 613-625.
5. FREEMAN, E. A., and SHELDON, J. H. Cranio-carpo-tarsal dystrophy; undescribed congenital malformation. *Arch. Dis. Childhood*, 1938, 13, 277-283.
6. KEITH, A. Concerning the origin and nature of certain malformations of face, head, and foot. *Brit. J. Surg.*, 1940, 28, 173-192.



FIG. 8, A and B. Accentuation of longitudinal arches, and elongation of both great toes with hallux valgus, more prominent on right.

DENTAL AIDS IN THE TREATMENT OF CANCER OF THE HEAD AND NECK*

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THE treatment of cancer of the head and neck involves many special problems of a dental and mechanical nature in which the dentist can be of considerable assistance. These special problems include prophylaxis, radiation protection, preoperative preparation of the mouth, and post-operative rehabilitation.

The majority of patients suffering from cancer of the oral cavity present a marked degree of oral sepsis, often due to neglect of long standing but always aggravated by the pain and tenderness of ulcerated and infected primary tumors. Radiation therapy of the tissues of the mouth always aggravates the oral sepsis but this complication

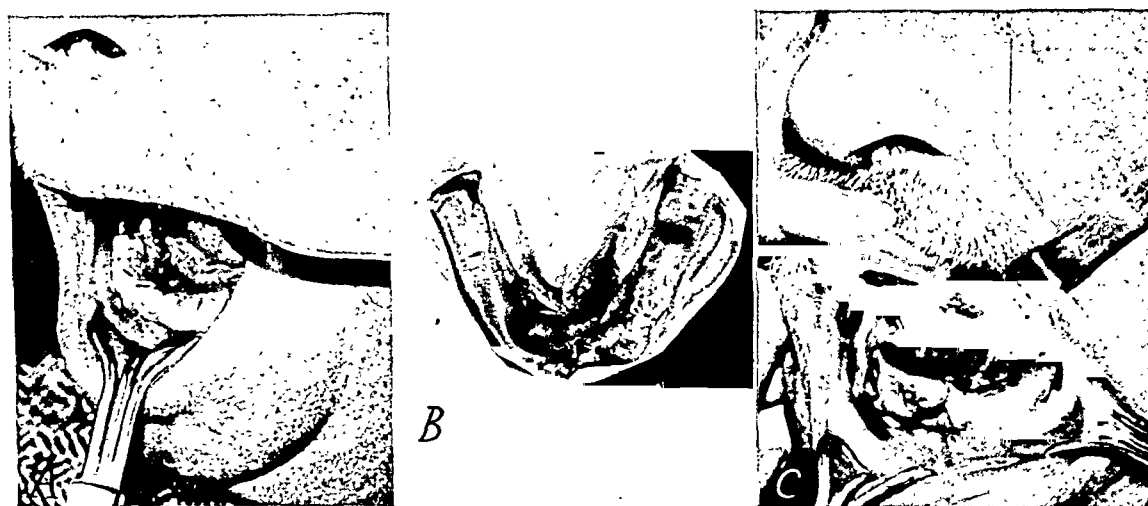


FIG. 1. *A*, squamous carcinoma in anterior floor of mouth. *B*, lead shield. *C*, lead shield in position.

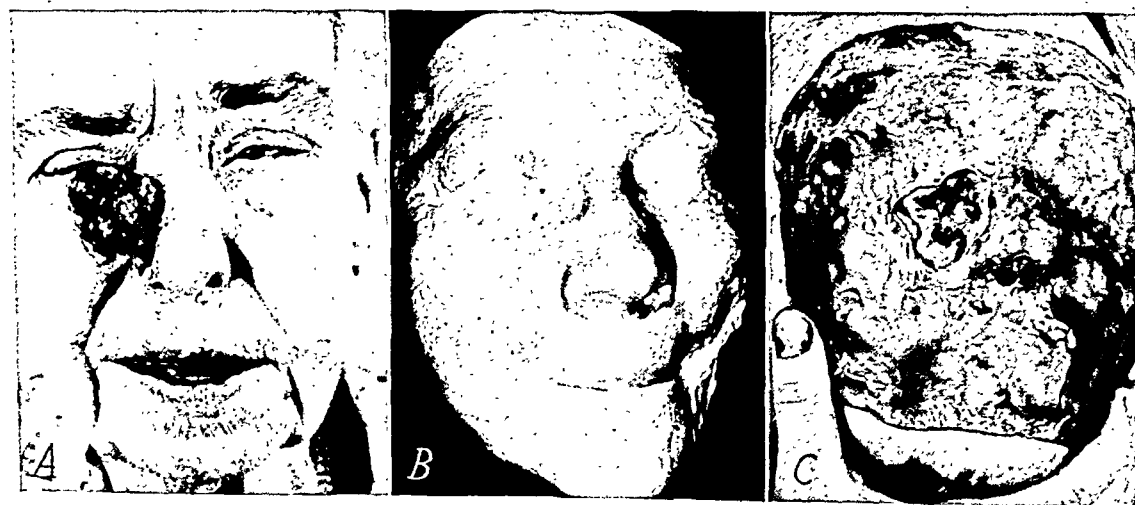


FIG. 2. *A*, basal cell cancer on the face. *B*, stone model in which lead shield is swaged. *C*, lead shield on face showing aperture through which lesion is irradiated.

* Presented at the Twenty-ninth Annual Meeting, American Radium Society, Atlantic City, N. J., June 9-10, 1947.

can be reduced by various dental procedures which include:

1. Scaling of the teeth.
2. Extraction of loose, jagged, carious teeth, which are obviously condemned.
3. Extraction of teeth to permit insertion of an intraoral roentgen-ray cone making possible direct irradiation of the lesion.
4. Preparation of intraoral lead shields to

protect normal structures from the deleterious effect of roentgen rays (Fig. 1).

5. Preparation of lead shields to permit irradiation of cancer of the face with protection of the surrounding normal tissues (Fig. 2).

Preoperative Working Models. Prior to any operative procedure, it may often be desirable to make models of the upper and

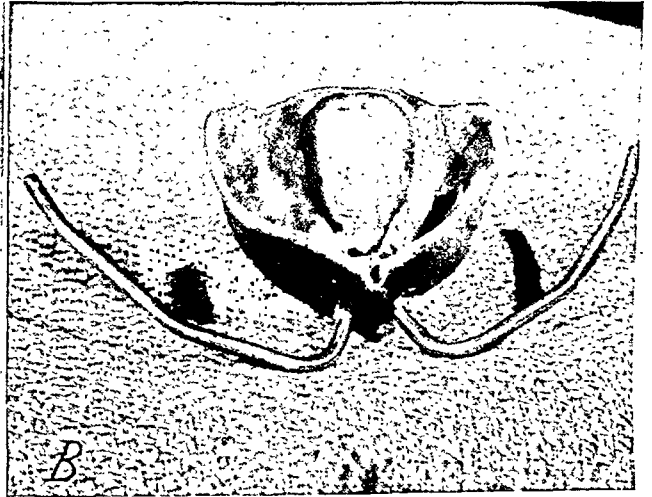
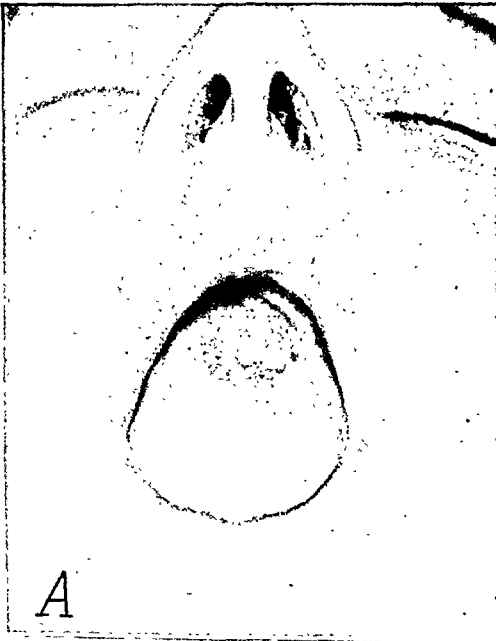


FIG. 3. *A*, hornified granuloma on hard palate. *B*, Kingsley type stent for retention of skin graft. *C*, stent and graft in position. *D*, result after grafting.

lower jaws so that the models may later be used as a basis for the construction of stents, splints, and prosthetic restorations.

Stents. In certain cases, where the surgeon plans to employ a skin graft to cover a mucosal defect in the oral cavity, a stent mold may be constructed preoperatively to provide fixation for the graft (Fig. 3).

the loss of portions of the roof of the mouth. Such defects may vary from a small opening to complete loss of the entire palate. Repair may be accomplished by surgery, prosthesis or a combination of both. Surgical reconstructive procedures may be successful for closing the smaller defects, but larger ones are more easily corrected by a



FIG. 4. Stout type splint used to immobilize the two halves of the mandible following separation at the symphysis during surgery.



FIG. 5. *A*, small operative defect of hard palate. *B*, prosthesis used to correct defect.

Splints. When it is necessary to immobilize portions of the mandible preoperatively or postoperatively, a splint may be constructed from models which were made prior to operation (Fig. 4).

Maxillary Prostheses. Surgical removal of growths arising in the nasal cavity, the paranasal sinuses, the alveolar ridge, and the hard and soft palates frequently entail

prosthesis (Fig. 5 and 6).

Since there is always a possibility of post-operative recurrence of the growth, closure of the defect by surgical repair may make it difficult or impossible to discover a recurrence in the early stages because the area cannot be thoroughly examined. On the other hand, if a prosthetic appliance is employed to correct the defect, this device

can be readily removed for periodic examination, thus enabling the surgeon to detect and treat any recurrence when it is still localized. The mechanical restoration of normal function is accomplished with a minimum of delay and without further hospitalization, permitting the patient to return promptly to a normal life.

Prosthetic appliances are to be preferred for the correction of the larger maxillary

speaking clearly and take nourishment by mouth. This problem is solved by providing a denture with an extension that seals off the mouth from the nasal cavity. Such an appliance is called an *obturator denture*.

A simpler temporary denture can be constructed as soon as wound healing permits. With such an appliance the patient may leave the hospital and carry on without too much disability until such

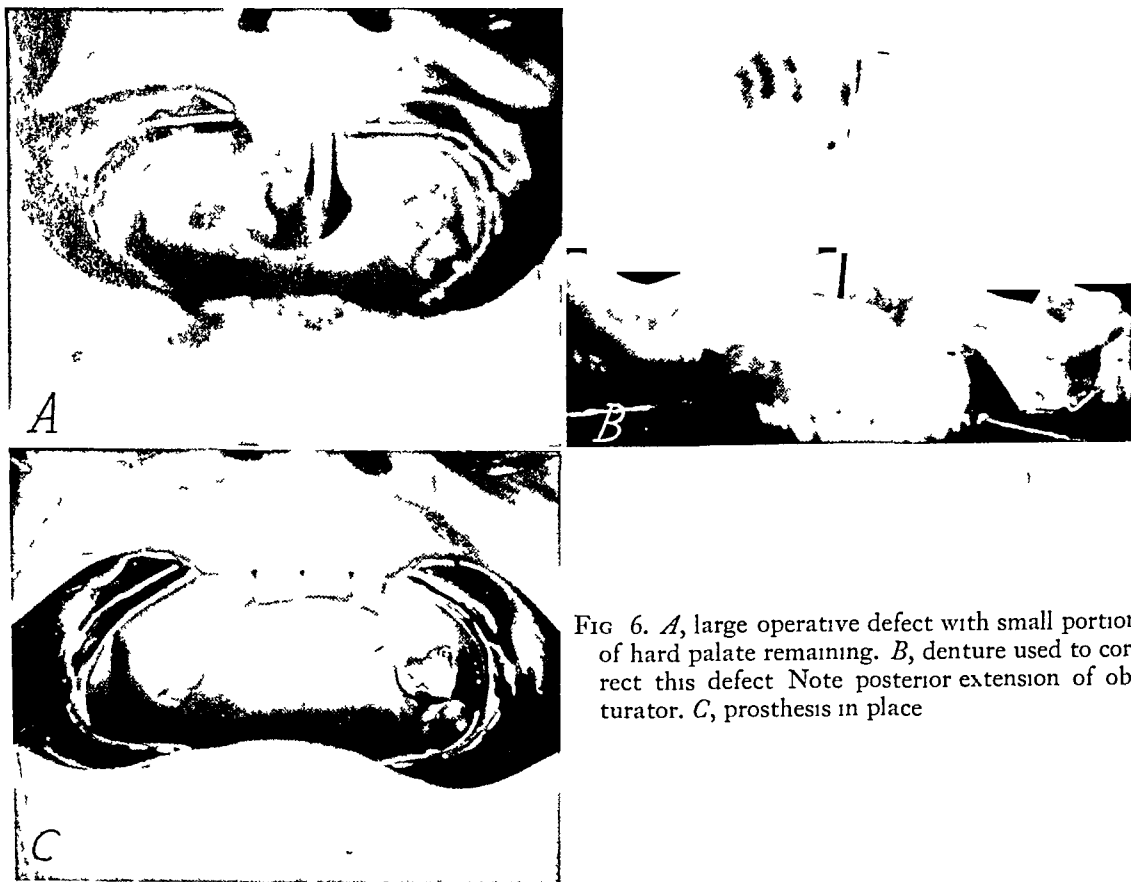


FIG. 6. *A*, large operative defect with small portion of hard palate remaining. *B*, denture used to correct this defect. Note posterior extension of obturator. *C*, prosthesis in place

defects, at least until such time has elapsed as to be reasonably certain that local recurrence will not occur. Without such immediate prosthetic restoration the morale of the patient during this period of observation would be poor. Speech would be seriously impaired and oral alimentation would be difficult if not impossible. The first requirement in these cases, therefore, is to construct some kind of temporary appliance which will enable the patient to

time as he is ready for a permanent appliance. The temporary appliance should be light in weight and should not extend too far into the defect to interfere with wound healing (Fig. 7). The time for the construction of a permanent appliance varies with each individual case. When epithelialization and wound contracture are complete and the tissues lining the defect have taken on a normal appearance (about two to three months following oper-

ation) the permanent denture may be made.

A good functional obturator must not only tightly seal the opening but must also be held firmly in place. Retention is obtained by utilizing the remaining teeth and by providing extensions of the obturator into the nasal cavity and the antra when these regions are exposed by the defect (Fig. 8).

palate (Fig. 9). Here the patient is without any masticatory apparatus whatever, and speech is entirely nasal and unintelligible. Nevertheless, an obturator denture can be made to close this large opening. In these cases the anterior and posterior portions of the nasal cavity are used as retention points. The posterior extension of the obturator, which is fixed, rests on the floor of

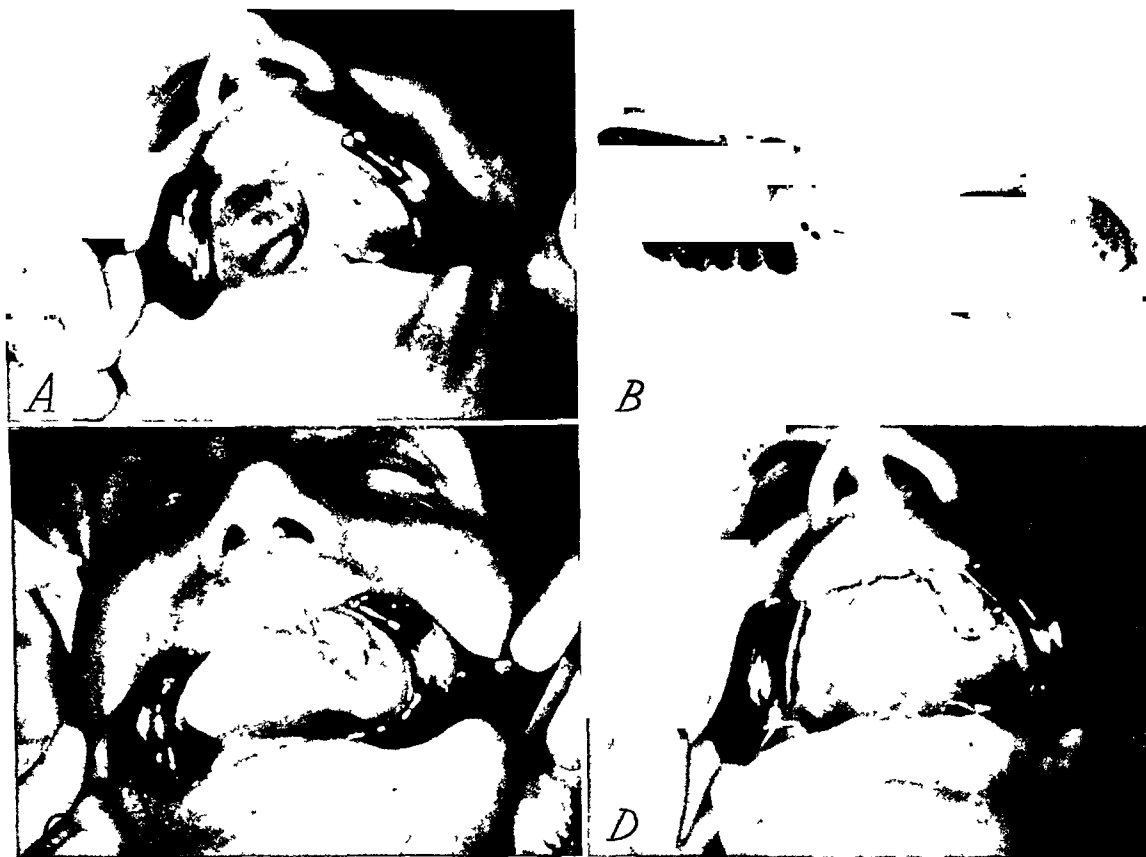


FIG. 7. *A*, operative defect of hard and soft palate. *B*, temporary and permanent dentures. *C*, temporary denture in place. *D*, permanent denture in place.

The correction of a defect following unilateral resection of the maxilla is not too difficult, especially when teeth remain on the opposite side. A posterior extension of the obturator portion of the denture, which rests on the floor of the nasal cavity, and clasps applied to the remaining teeth are usually sufficient to retain such a denture.

The most extensive operative defect occurs with complete loss of the entire

the nasal cavity. The anterior extension is movable, retracting forward and backward, to permit insertion and removal of the denture. This anterior extension, when in its forward position, rests on the nasal spine (or scar tissue in this region when the spine has been excised) (Fig. 10). This hinged component of the obturator includes several anterior teeth so that the patient may easily insert and remove the denture. On

insertion of the obturator the hinged section is held forward while the posterior

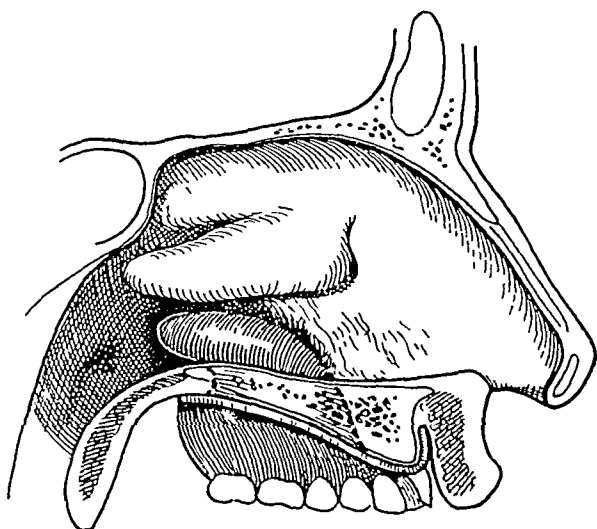


FIG. 8 Sagittal section of obturator denture showing posterior extension resting on floor of nasal cavity.

portion is placed in position. Then the anterior portion is set into place and the movable section is pushed backward, thus bringing the anterior extension forward to rest in the region of the nasal spine. A small pin locks the part in position. To remove the denture the procedure is reversed.

Mandibular Prostheses. The treatment of tumors in or about the mandible often requires radical surgical procedures. When the mandible has been resected to include one of the temporomandibular articulations there occurs a loss of normal occlusion between the upper and lower teeth. The mechanical principles of such a problem might be illustrated as follows: When a toilet seat is raised or lowered, it swings through an even arc so long as the two hinges are intact; but if one of the hinges is detached, there is no definite position into

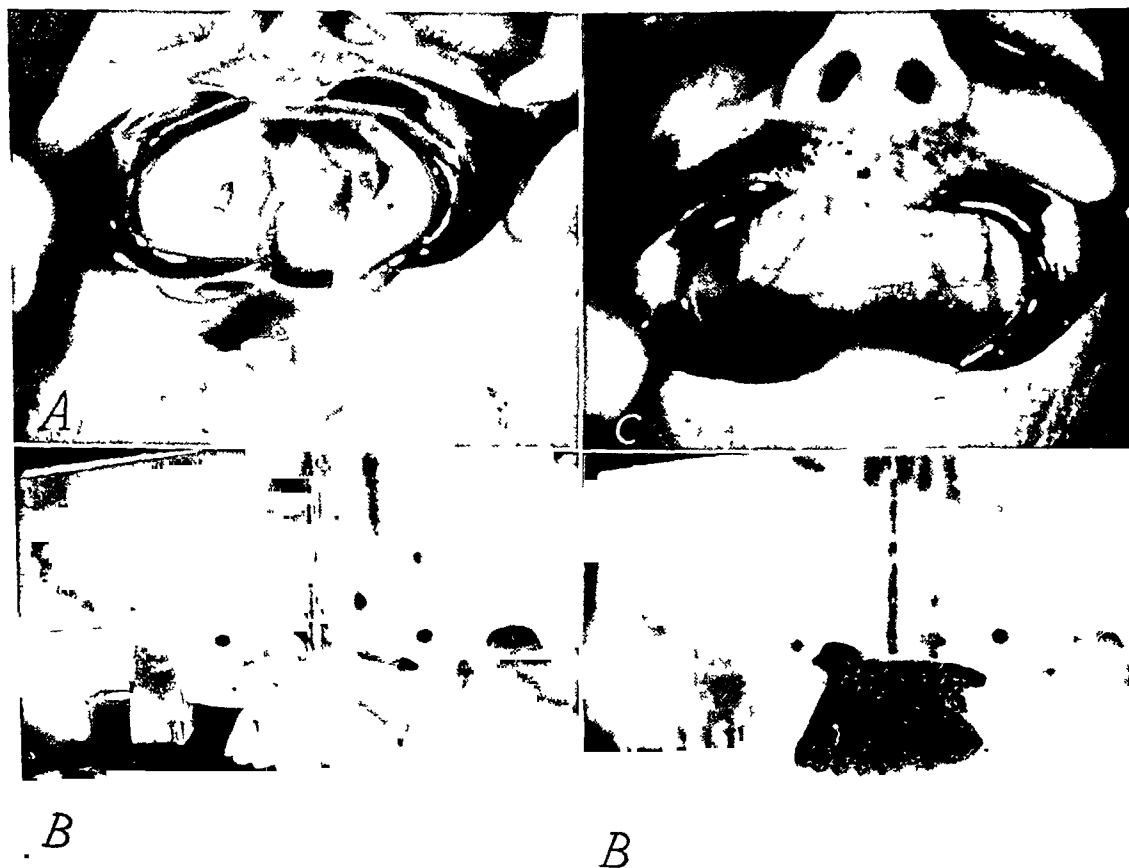


FIG 9 A, operative defect showing complete loss of hard and a portion of soft palate. B, denture used to correct the defect. C, denture in situ.

which the seat will fall. To correct such a condition, therefore, some mechanical device must be constructed which will guide the mandible into its normal position.

As a temporary means of maintaining the remaining portion of the mandible in a relatively normal position immediately after resection of the mandible, several methods may be used. With one of these methods—intermaxillary wiring (Fig. 11)—the remaining teeth of the mandible are held in occlusion with the upper teeth in a fixed position. A second method consists in the construction of a temporary splint—a cast silver splint fitting over the lower teeth with a buccal flange which rests against the buccal surfaces of the upper teeth (Fig. 12). This latter type of appliance permits the patient to open and close the jaws but will not permit the remaining portion of the mandible to be drawn mesially and backward. The maintenance of this occlusion is desirable during the early stages of healing following jaw resection, for it will prevent scar tissue from retracting the mandible backward and to the affected side.

After complete healing in a typical case of unilateral jaw resection, the face is flattened on the resected side. The remaining mandible is drawn inward and backward and there is a definite loss of occlusion with the upper teeth, leaving the patient with greatly impaired masticatory function (Fig. 13). The greatest discomfort, however, occurs while the patient is sleep-

ing. During this time the mandible is subjected to unopposed pressure while the patient twists and turns in his sleep. The corrective measures to be considered in these cases are mainly restoration of function to the remainder of the mandible and cosmetic improvement if it can be obtained without excessive pressure on the scarred areas.

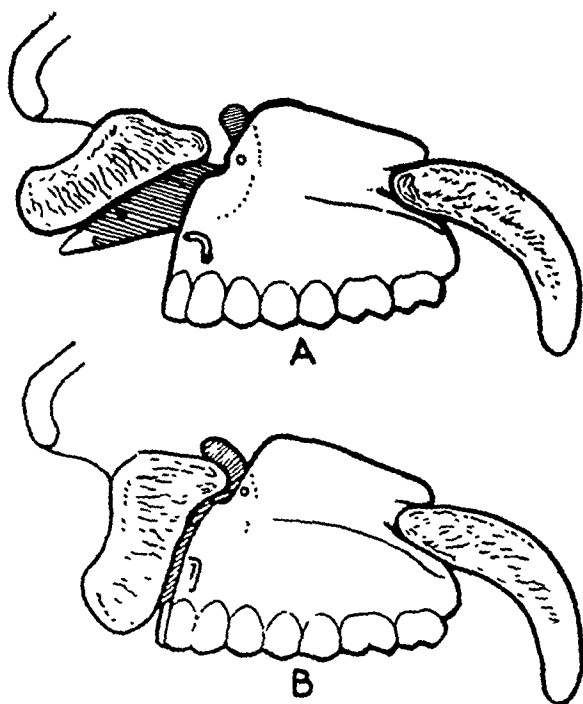


FIG. 10. *A*, posterior portion of denture in position with extension resting on floor of nasal cavity. Anterior extension is retracted by bringing movable section forward, thus permitting insertion of denture. *B*, anterior extension in retentive position.

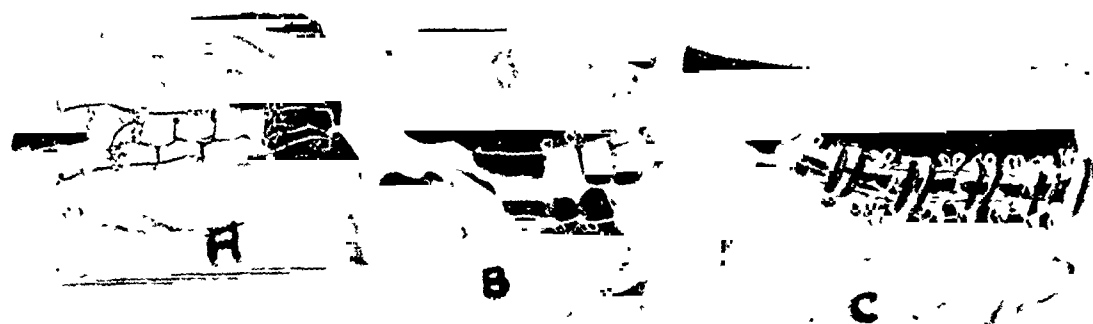


FIG. 11. Types of intermaxillary wiring: (*A*) the eyelet or loop method; (*B*) continuous loop; (*C*) the arch wire.



FIG. 12. Silver flange resting on buccal surfaces of upper teeth guide the mandible in its normal position.

Let us consider first the restoration of mandibular function. Since there is no hinge on the resected side, the first step must be to construct a pseudo-temporomandibular joint. In my opinion the best site for such a hinge is in the region of the upper third molar. Through many years of experimentation with different types of hinges which may be employed in these cases, the ball and socket type has been

found to be most satisfactory in the majority of such patients (Fig. 14). The socket portion is a split tube which is connected to some form of upper denture. In an edentulous mouth the artificial joint may be incorporated in a full denture. Since the distance from this split tube or socket, located in the third molar region, is much shorter when measured from the symphysis menti than from the temporomandibular



FIG. 13. *A*, appearance of patient without appliance. *B* and *C*, appliance with pseudo-temporomandibular joint held in position by gate clasp. *D* and *E*, appliance in position guiding remaining mandible in its normal path.

joint on the opposite side, an additional hinge must be incorporated into the lower appliance. This hinge is best placed in the cuspid region of the resected side (Fig. 15). The split tube above and the ball arm (connected to the lower appliance) permits the insertion of the lower denture independently of the upper. The combination of the split tube and the ball and socket hinge above, allows all normal movements of the mandible, including protrusive and lateral excursions. The appliance is so designed

lingual portion of the appliance by a hinge in the posterior region. When the gate is closed, it is held firmly in position by the specially designed male and female lock located anteriorly, which permits conve-

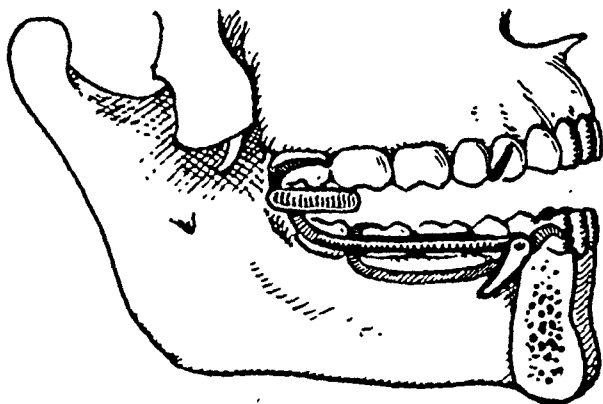


FIG. 15. Location of pseudo-temporomandibular joint in relation to the true joint on the remaining mandible.

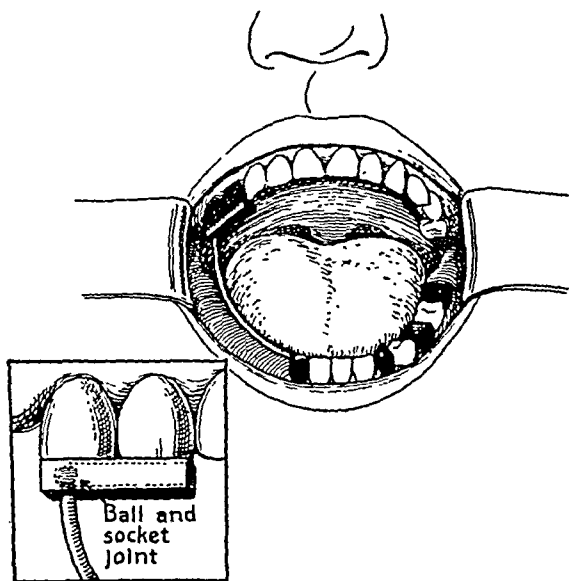


FIG. 14. Pseudo-temporomandibular joint of ball and socket type, using split tube.

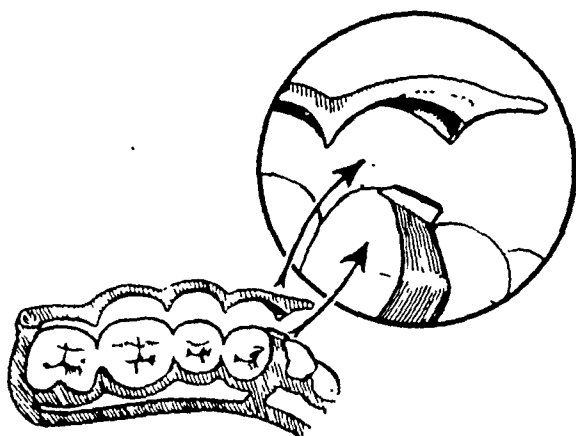


FIG. 16. Diagram showing gate clasp with hinge at posterior portion of lower denture and anteriorly male and female type lock.

that when the mouth is closed it automatically thrusts the remaining portion of the mandible over into normal occlusion with the upper jaw. Obviously this type of appliance must be held securely in position and the stress should be distributed on as many teeth as possible. Ordinary claspings of the teeth is inadequate to retain the lower denture in its position. Therefore, a special hinge clasp has been designed (Fig. 16). The lower denture will have a lingual bar with a continuous clasp running along the lingual surface of all of the remaining teeth. A continuous gate or hinge clasp is so designed that it will fall below the height of contour of the buccal and labial surfaces of the teeth. This clasp is connected to the

nient opening and closing of the gate for removal and insertion of the denture. When the gate is closed, the stress exerted by the lower appliance is evenly distributed on all of the encircled teeth. Many types of clasps have been tried over a period of years, but this particular design has been found most successful.

Moderate cosmetic improvement following resection of the mandible may be achieved by the addition of an acrylic saddle to the lower appliance, extending as



FIG. 17. *A*, edentulous mouth in unilateral jaw resection. *B*, pseudo-temporomandibular joint incorporated in upper denture. Note special design in lower hinge used to create downward pressure. *C*, ash spiral spring used on side of remaining mandible. *D* and *E*, dentures in position.

far back as the scarred tissues permit. Missing teeth may be included in the saddle and modifications of this design may be made to suit individual cases. Although no two cases are alike, this general principle may be employed in all.

Following resection of the mandible in edentulous individuals, the more difficult

problem of functional prosthesis arises. In these cases the ball and socket type of hinge is used on the resected side while a spiral spring is employed on the opposite side (Fig. 17). This spring exerts a force which tends to separate the two dentures; but since the upper jaw is immovable, it actually forces the lower denture downward

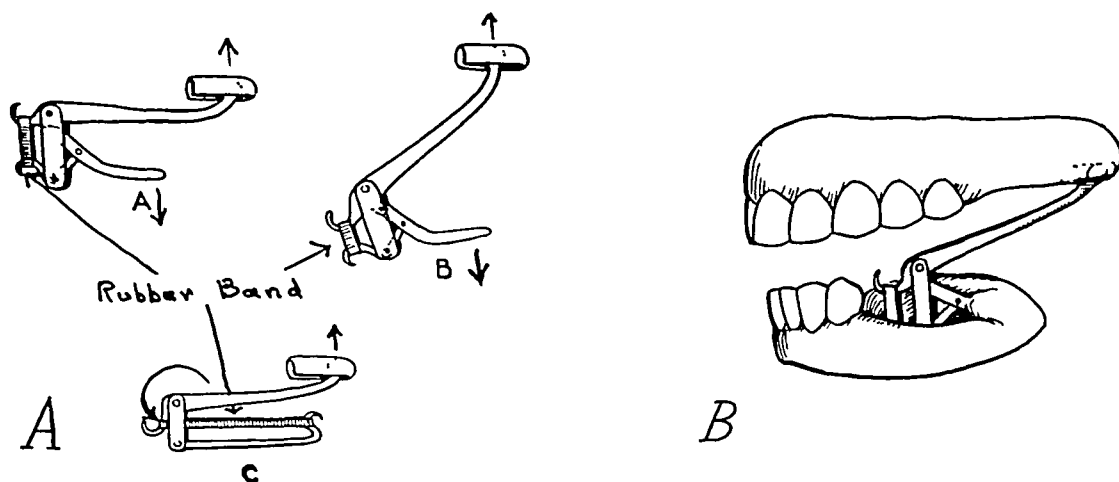


FIG. 18. *A*, (*c*) simple method utilizing rubber band to force bar upward. Here the denture would rotate around hinge allowing heel of denture to rise. (*A* and *B*), more complex method whereby the downward force is directed at the heel of the denture. *B*, The bar and hinge assembly in the dentures.



FIG. 19. *A*, patient following cautery excision of the nose. *B*, prosthesis used to restore lost structure.

in position. A similar downward pressure must also be provided on the opposite side where the artificial joint is employed. A simple method illustrating these principles is shown in Figure 18*A*. This design has a hook attached to a right angle extension of the bar just below the hinge and another fixed to the denture posteriorly. A rubber band is stretched between these two hooks

which exerts a pull and tends to draw the two hooks together, thus producing upward pressure on the ball end of the bar. The disadvantage of this type of hinge is that the denture rotates around the hinge thus raising the posterior heel of the denture. A more complex but more satisfactory device is shown in Figure 18, *B* and *C*. Here the downward pressure is at the posterior end

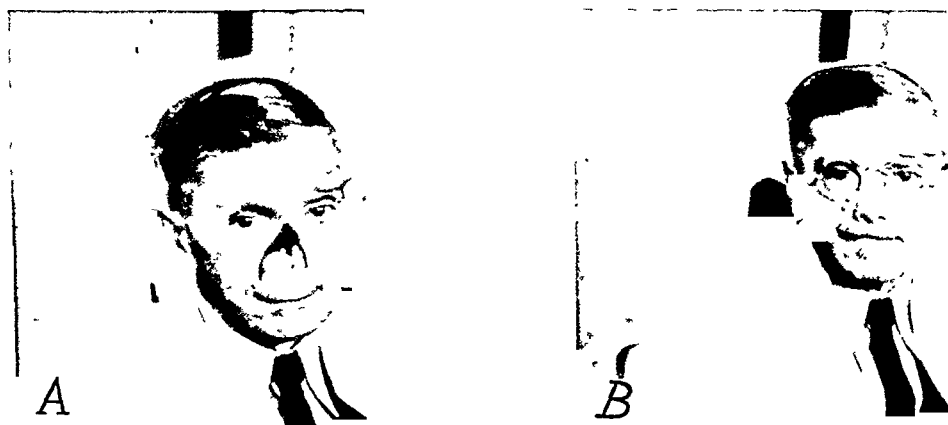


FIG. 20. *A*, large defect with nose and portion of face missing. Patient undergoing plastic repair. Note tube pedicle on forehead. *B*, temporary prosthesis.

of the denture, thus preventing its displacement.

Facial Prosthesis. Many unsightly defects follow treatment of cancers of the skin of the face, the nasal cavity and maxilla, and surgical repair of some of these extensive defects is often technically impossible, inadvisable and not feasible for other reasons. Where the restoration has been obtained by a facial prosthesis, the surgeon can readily examine his patient and easily detect early recurrence. If the defect is corrected by surgery, the area is not accessible to examination and a recurrence may not be noted until it has reached considerable proportions (Fig. 19). Many patients would prefer to wear a prosthetic appliance rather than endure the long period and expense of

hospitalization and multiple operations. In any event, a facial prosthesis may be employed for temporary correction to carry the patient through such a period until it is deemed advisable to proceed with reconstructive surgical procedures (Fig. 20).

The materials which are available at present for the prosthetic reconstruction of facial defects leave much to be desired, but a fair cosmetic result can nevertheless be obtained. These media include latex, acrylic resins and vinyl resins, and others. In my experience vinyl resins have given the most satisfactory results since they are more durable than the other available materials.

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ROENTGEN TREATMENT OF CANCER OF THE ESOPHAGUS*

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CERTAIN criteria have been established for the treatment of carcinoma of most organs, which leaves no doubt as to the proper procedure at every stage of the disease. Up to the present, such data are not available for the treatment of cancer of the esophagus. The radiotherapist, surgeon, and especially the general practitioner, are often at a loss as to what to advise the patient suffering with esophageal malignancy. No great measure of enthusiasm exists for present day procedures, whether surgery or irradiation, and some physicians regard every type of treatment as hopeless. Unquestionably, such confusion delays treatment for some patients until all hope for cure or palliation is lost. It is important, therefore, that clinical research be continued, especially with surgery and irradiation, so that these methods can be improved. With this in mind, the writer intends to re-evaluate present day treatment of cancer of the esophagus, to relate our experiences at the Montefiore Hospital with radiation therapy for this condition, and to report a case treated by roentgen rays and well for more than seven years. So that others may profit from our experiences, complications are discussed which are associated with this intensive irradiation.

CHOICE OF A METHOD OF TREATMENT

The two principal therapeutic procedures are irradiation and surgical excision. Isolated five year survivals have been reported for both of these methods, but no figures exist for large groups which might serve as a basis for comparison of these measures. There are other important considerations. Watson,²¹ presenting clinical observations on 930 cases, states that only

48 per cent of the patients coming to autopsy showed no discoverable evidence of metastases. Gross and microscopic lymph node involvement was demonstrated in 40 per cent, and in 36 per cent the disease extended into the trachea or bronchus. These observations suggest that even under the most optimal conditions, surgery is possible for only a small group. This is further borne out by surgeons who have noted that of the small group considered operable, about 75 per cent are found to be inoperable when explored. Irradiation, on the other hand, is feasible for all except terminal cases. However, as with surgery, cures are difficult to achieve with irradiation. The response to radiotherapy is not similar for all regions of the esophagus. The best results have been reported for the lesions in the upper third, and especially in the cervical portion of the esophagus.^{3,17,22} This must, in great measure, be due to the fact that the carcinoma in these locations is closer to the surface, and therefore is more likely to receive adequate dosage, and to the histopathology, which is more apt to be radiosensitive epidermoid carcinoma. Also, post-irradiation sequelae, such as fibrosis, are less damaging and less likely to result in a fatality, since fewer vital structures are present in the neck and superior mediastinum. Another consideration is mortality. The death rate from irradiation is very low, that of the radical operation, high, except in very experienced hands. Exact mortality figures are not available for surgery or irradiation. To sum up, surgery, in competent hands, is the treatment of choice for operable cancer of the esophagus.^{1,5,7,11,18,19} Since the majority of these growths are inoperable when first seen, the only treatment available for these patients is radiotherapy.

* From the Department of Radiotherapy of the Montefiore Hospital for Chronic Diseases, New York. Presented at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 9-10, 1947.

CONTRAINDICATIONS TO THE USE OF RADIOTHERAPY

1. *Infection* at the site of or adjacent to the esophageal lesion. The injury induced by intensive irradiation diminishes the resistance of the tissues to bacteria. The resulting infection may lead to perforation of the esophagus. Irradiation is also dangerous in the presence of a mediastinitis. Temperature and pulse rate are very important diagnostic aids, and should be charted daily. A persistently rapid pulse, with or without fever, usually is the first sign of mediastinitis.¹⁵ A wise procedure in the treatment of these cases is to start with small doses to clear up the infection, and then slowly increase the irradiation to the large amounts necessary to control the carcinoma. In this way, perforation and other complications may sometimes be avoided.

2. *Severe anemia* due to repeated hemorrhages or to toxic absorption. Irradiation can be instituted after transfusions have corrected the anemia.

3. *Cachexia and Emaciation*. They are usually indicative of far advanced disease, esophageal obstruction or both. In these patients, intensive radiotherapy, with intent to cure, may aggravate the ailment. Gastrostomy and palliative radiotherapy, however, may be followed by temporary alleviation of symptoms.

TECHNIQUES OF RADIATION TREATMENT

1. *Interstitial*. The introduction of radium seeds into the tumor, once a common method of treatment, has been abandoned by most radiotherapists. Except for very early lesions, it is difficult to accurately implant the seeds so as to obtain homogeneous irradiation. The danger from perforation is greatly enhanced by radium puncture.

2. *Intracavitary*. Several radium tubes are placed in tandem in an applicator corresponding to the total length of the lesion, and then introduced into the esophagus.⁸ This method has several disadvantages. If the cancer is obstructing, it is difficult to

pass the upper limit of the tumor. The trauma attending the insertion may lead to perforation. The narrow lumen at the site of the lesion makes it impossible to treat at any distance with resulting low depth dosage and insufficient irradiation of the deeper portions of the growth. The accurate placing of the applicator is difficult and occasionally impossible, since the inferior limits of the lesion cannot always be determined with accuracy.

3. *Telecurietherapy*. Treatment with radium at a distance is rarely employed for carcinoma of the esophagus. Few institutions possess the special applicator and the large amounts of radium required. When utilized, it is used very much like a roentgen-ray tube, and the site of the cancer is cross-fired through several portals of entry.

4. *Roentgen Therapy*. Roentgen therapy is the treatment of choice for inoperable carcinoma of the esophagus,^{2,3,12,14-17,20-23} also for operable growths where adequate surgery is not available. The lesion is cross-fired from many portals. High voltage radiation, heavily filtered and long target distance, 50 cm. or over, should be utilized. A series of daily treatments is given over a period of five to eight weeks.

5. *Combined Technique*. Intracavitary or interstitial radium therapy may be sufficient to destroy small flat growths. These procedures will not destroy bulky or infiltrating carcinomas. In many instances, the adjacent lymph nodes are early involved. This means that additional radiation must be supplied to these outlying areas, if growth is to be controlled for any length of time. This is best accomplished by supplementing the radium therapy with external irradiation. Zuppinger²³ is one of the better known exponents of this method.

FACTORS GOVERNING THE RESPONSE OF ESOPHAGEAL CARCINOMA TO IRRADIATION

A. *Radiosensitivity*. Malignant tumors of the esophagus are, as a rule, of the squamous cell type. Adenocarcinomas are occasionally seen, usually in the lower esopha-

gus in the region of the cardia. Squamous cell tumors have been subdivided into types or grades which have varying degrees of radiosensitivity. The majority of the esophageal tumors are of the mucous membrane type, a group considered radiosensitive. A much smaller number show the more radioresistant cutaneous differentiation.²³ Broders and Vinson⁴ describe carcinoma of the esophagus as a tumor of a high degree of malignancy with marked cellular activity and little tendency to cell differentiation. They graded 207 cases; 7.73 per cent, Grade 2; 45.9 per cent, Grade 3; and 46.37 per cent, Grade 4. Watson,²¹ in his clinical discussion of 930 cases of esophageal malignancy, found squamous cell carcinoma the most common form and nearly 83 per cent of them were in Grades 2 and 3. Grade 4 and transitional types of carcinoma occurred in about 3 per cent, and growths in about 9 per cent of all cases were adenocarcinomatous. The histopathological findings indicate a high degree of radiosensitivity for the majority of esophageal tumors. Radiosensitivity, however, does not of itself imply radiocurability. The other considerations to be enumerated are equally important.

B. Clinical Character of the Neoplasm. The two clinical groups encountered are the exuberant papillary type and the infiltrating ulcerating form. The exuberant papillary lesion has a tendency to grow into the cavity of the esophagus, does not infiltrate the lymphatics early, and gives the best response to irradiation. They constitute only about 50 per cent of the cases.^{8,23} The infiltrating ulcerative type early infiltrates the lymphatics, carrying metastases and infection to distant areas. It is more radioresistant and difficult to treat because of infection and metastases.

C. Stage of the Disease. Radiation treatment of carcinoma of the esophagus is primarily a local therapy. Permanent healing is therefore more easily achieved with growths in the early stages when it is most apt to be localized. If the disease spreads to the lymph glands, or if distant metastases

have taken place, there is little chance for cure with radiotherapy.

D. Accessibility. The esophagus is most accessible to the external forms of radiation (roentgen radiation and teloradium). If a real attempt is made to control the malignancy, the dosage to the tumor must be adequate. With the intensive irradiation necessary to give such dosage, there is great danger of causing severe radiation damage to the esophagus, mediastinum and lung. Treatment should be planned to avoid or minimize such injury.

E. Previous Treatment. Following previous irradiation, a second favorable result is difficult to achieve by another course of treatment, even if the tumor earlier had temporarily disappeared. Because of the damage, chiefly vascular, induced by the previous irradiation, there is interference with the nourishment of the tumor and the normal surrounding tissues. This results in a reduction of the radiosensitivity of the neoplasm, and an increase in the sensitivity of the normal cells. Under these circumstances, a second course of treatment is rarely successful. Such injury may also be the basis for later lung damage, although no discernible lung trauma resulted from the earlier irradiation.

The course of radiological healing is sometimes influenced by previous operative procedures at the site of treatment. Surgery may interfere with the local circulation, and thus render the tissues to be treated more susceptible to radiation trauma. The necessary reduction in dosage to avoid such injury may be the difference between a cure and failure.

Method of Treatment. The successful treatment of carcinoma of the esophagus is based both on a thorough clinical knowledge of this disease and of the principles underlying radiation therapy. In planning the roentgen therapy of a given case, there are several factors which are important. They are the quality of the ray to be employed, the daily and total tumor dose and the technique of application.

1. Quality of Roentgen-Ray Voltage.

Some of the cases of carcinoma of the esophagus reported in the literature as controlled for varying periods were treated with roentgen rays generated with 200 kv.^{2,12,14,16,23} To date, the best results from the roentgen treatment of cancer of the esophagus have been published by Smithers and collaborators,¹⁵ using 400 kv. roentgen rays. Buschke and Cantril,⁶ reporting their experiences with 800 kv. roentgen therapy, state their belief that supervoltage has definite advantages over 200 kv. radiation in the treatment of intrathoracic esophageal cancer. More recently, Holmes and Schulz,⁹ reviewing eight years' work with 1,200 kv. therapy, found no increase in survival time over the older methods. In their series, the planned dose at the site of the tumor was 3,000 r, and even this dose was not always given. Their poor results may be due to the fact that dosage at the site of the tumor was low. At Montefiore Hospital, where 200 kv. and 400 kv. roentgen therapy is utilized, it is our clinical impression that 400 kv. irradiation has some superiority over the 200 kv. Two hundred kilovolt machines are more flexible, but with 400 kv., depth dosage is greater, skin reactions are less severe and lastly, radiation is better tolerated by the patient.

2. Dose. Intensity of the Radiation. Carcinoma of the esophagus responds poorly to irradiation unless the daily and total tumor doses are adequate. The lethal dose for squamous epithelioma is at least 5,000 r, in most instances. For esophageal carcinoma, Smithers¹⁵ advocates a tumor dose of 6,000 to 7,000 r, delivered in six weeks. Nielsen¹⁴ believes a tumor dose of 5,000 to 6,000 r in thirty to forty days would improve results. In a series of cases that he published, those patients who remained well for two years had received a tumor dose of 4,350 to 5,000 r, over a period of thirty-five to forty days. Strandqvist,¹⁶ reporting the material at Radiumhemmet, also advises a tumor dose of 5,000 r, delivered in forty days. Two cases, arrested two and three years respectively, received tumor doses of 4,350 to 5,000 r in thirty-

five to forty days. I have a case treated by roentgen radiation and living over seven years, in whom the tumor dose was 5,500 r, given in thirty-eight days. To deliver these large doses with 200 kv. and 400 kv. radiation, many treatment fields are necessary. Levitt¹² has long advocated multiple fields, and three anterior and three posterior portals have been used for many years in England, at Radiumhemmet in Sweden, at Montefiore Hospital and other institutions.^{12,15,16} Smithers and his collaborators¹⁵ utilize six narrow fields, arranged in three sets of directly opposing pairs: a direct anteroposterior pair, measuring 15 by 6 cm. each, and two oblique pairs, measuring 15 by 4 cm. each; fields so arranged that the center of each anterior oblique field is 7.0 cm. from the midline and that the central rays from all six fields meet at the center of the tumor. This arrangement gives the highest dose to the tumor and at the same time delivers as small a dose as possible to the more sensitive of the normal structures in the thorax.

Other important features of the treatment are the localization of the tumor and determination of the angles for irradiation of the oblique fields. This information may be obtained in the following manner. The patient is roentgenoscoped in the horizontal position. The site of the tumor is visualized by having the patient swallow barium. The upper and lower limits of the growth are marked on the skin of both the anterior and posterior chest wall. The treatment portals extend several centimeters above and below the marks. Posteroanterior and lateral roentgenograms are taken at 6 feet to determine the position of the esophagus. The anteroposterior diameter of the chest is then measured, taking several points at the level of the growth, and a cross section drawing is made of the chest. The position of the esophagus is determined from the lateral roentgenograms and recorded in the drawing. The six treatment fields are marked out on the diagram and lines drawn from the center of each portal to the center of the esophagus. The angles of the oblique fields are measured and recorded. These

angles are used in positioning the tube when the radiation is given. It is very important that the patient lies flat, and is not rotated during treatment. Some patients are now treated in a sitting position. In these cases, beam direction for the oblique portals is obtained by a modification of Mayneord's collineator, an optical device for the alignment of a roentgen-ray beam.¹³

To insure an adequate daily and total tumor dose within a period of six to eight weeks, large amounts of radiation must be given at each treatment. Excessive damage

gen treatment of cancer of the esophagus in an effort to improve our results. Patients have been treated with multiple fields and with large daily doses, but the plan of irradiation has varied. The cases to be reported have been selected because of special features to be presented.*

Severe Irradiation Changes in the Lungs and Mediastinum Following Intensive Irradiation.

CASE 1. (Montefiore Hospital No. 27640) G.R., male, aged sixty-three.

TABLE I

Date	Field	Size	Dose	Kv.	Ma.	Filter	Distance
11/16-11/23 1936 I	Ant. and post. mediastinum R. ant. medial lung L. ant. medial lung	12×8 cm. 12×8 cm. 12×8 cm.	1,600 r each 750 r 500 r	200	30	0.5 mm. Ag plus 1 mm. Al	70 cm.
12/7-12/12 1936 II	Ant. and post. mediastinum R. ant. medial lung L. ant. medial lung	12×8 cm. 12×8 cm. 12×8 cm.	1,500 r each 400 r 550 r	200	30	0.5 mm. Ag plus 1 mm. Al	70 cm.
12/29 1936- 1/4/1947 III	Ant. and post. mediastinum R. ant. medial lung L. ant. medial lung R. post. lung	12×8 cm. 12×8 cm. 12×8 cm. 12×8 cm.	1,525 r each 550 r 650 r 400 r	200	30	0.5 mm. Ag plus 1 mm. Al	70 cm.

to normal structures can be avoided if several fields are treated at each sitting. Although the total daily dose is high with this method, the amount of radiation to each field is not excessive. Smithers treats all the six fields daily, each receiving 100 r, 400 kv. If the treatment is uninterrupted, the tumor dose will be between 6,000 and 7,000 r in six weeks. For 200 kv. radiation, this daily dose should total about 500 r to two or more fields, for a period of about six weeks. Larger daily doses with 200 kv. radiation are poorly tolerated by the patients, and smaller amounts deliver an inadequate tumor dose. Under ideal conditions, the daily dose to the tumor should be in a range approximating 200 r and not less than 150 r.

ABNORMAL IRRADIATION RESULTS AND
COMPLICATIONS WITH SPECIAL REFER-
ENCE TO IRRADIATION INJURIES

At the Montefiore Hospital we have, for many years, varied our technique of roent-

This case is one of carcinoma of the esophagus, lower and middle thirds. The biopsy showed squamous cell carcinoma with beginning pearl and whorl formation. It was planned to give this patient three courses of irradiation of moderately high intensity. The method was based on the assumption that malignant cells would be damaged and a number destroyed by the first course. Cancer cells which persisted would be destroyed by the succeeding applications. The damaged normal tissues would recover in the intervals between courses, thus avoiding excessive injury to the lung. The details of the irradiation are noted in Table 1. Two to three fields were treated daily, and the individual doses varied from 250 to 400 r/o. The dosage for each course was calculated sufficient to produce an epithelitis of the esophageal mucosa.† Esoph-

* Some of these cases form part of a previous report by the author. Freid, J. R., and Goldberg, H. Post-irradiation changes in the lungs and thorax; a clinical roentgenological and pathological study, with emphasis on the late and terminal stages. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, 43, 877-895.

† Term applied to the reaction produced in the mucous membranes by the radiation. A pseudodiphtheritic membrane forms, which is due to necrosis of the superficial portion of the mucous membrane.

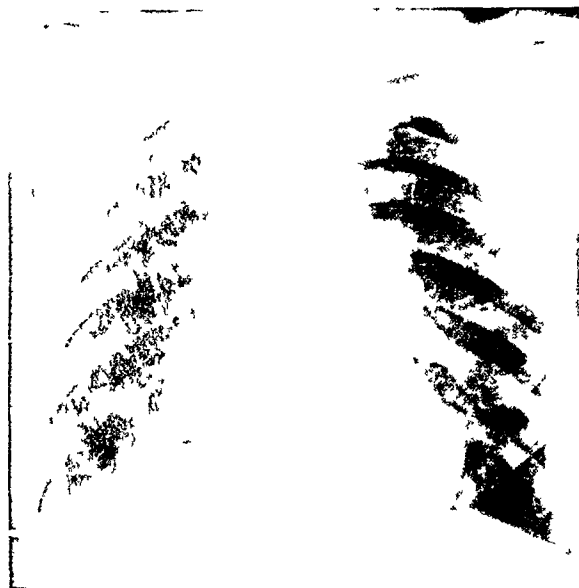


FIG. 1. Case 1. Lungs and mediastinum essentially negative. Roentgenogram taken three days following first course of irradiation.

agoscopy, following the first and third courses, showed the presence of such a membrane. The patient complained of difficulty in swallowing after each course. Two months following course III, a gastrostomy was performed because of dysphagia. His condition became progressively worse and roentgenograms over a period of nine months showed progressive fibro-



FIG. 2. Case 1. Dense fibrotic infiltration in the medial portion of the right lung six months following the third course of irradiation.

sis of the medial portion of the right lung, fibrotic infiltrations at the right base, elevation of the left diaphragm, and a left pleural effusion (Fig. 2). The patient died nine and one-half months following course III. The postmortem examination showed carcinoma of the esophagus with extension to the pleura and contiguous structures, but not to the lung; extreme fibrosis and atelectasis of the medial portions of the lungs; small effusion in the pericardium; and moderate hypertrophy and dilatation of the right auricle and ventricle.



FIG. 3. Case 1. Areas outlined indicate the the portals used for the irradiation.

Comment. The presence of an epithelitis in the region of the growth following courses I and III, would indicate adequate dosage at the site of the cancer. The probable reason for the failure to control the disease in this patient was the radioresistant character of the carcinoma and the extension of the growth outside the esophagus when irradiation was instituted. The severe radiation damage to the lungs was due not so much to the total dosage as to the high individual doses and large fields (Fig. 3). Massive doses, especially if repeated, and at close intervals, are likely to produce radiation damage even if the total

dosage is not high. Esophagoscopy should not be undertaken during or immediately following irradiation, because of the danger of perforation. It was done in this instance to study the effect on the esophageal mucosa of certain dosages.

Dysphagia Following Well Planned Irradiation May Be Due to Scar Formation and Contraction of the Esophagus and Not to Recurring Carcinoma.

the divided dose technique. The esophagus was cross-fired from six fields (Fig. 4). One field was treated daily. In the first course, the daily rose was 330 r/o and in the third and fourth courses, 250 to 300 r/o (Table II). The esophageal obstruction (Fig. 5) disappeared following the second course of irradiation. The third and fourth courses were given for recurring esophageal obstruction. Severe cough appeared three weeks after the final irradiation. Roentgenograms showed atelectasis of both lower lobes

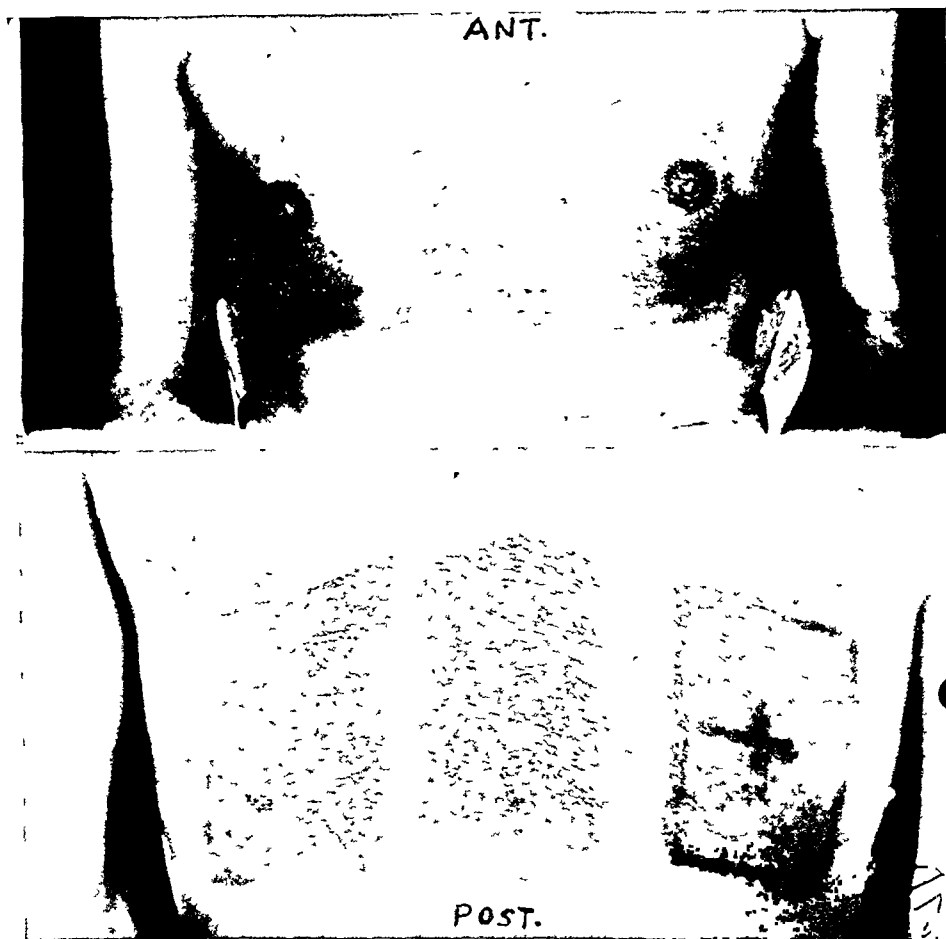


FIG. 4. Case II. Pigmented areas show the large portals used for irradiation.

Case II. (Montefiore Hospital No. 23973) L. K., male, aged fifty-two.

This patient had a non-differentiated carcinoma of the esophagus, lower third, of one year's duration. Gastrostomy was performed at another institution prior to his admission. The first course of irradiation was given elsewhere; the rest of the treatment was carried out at Montefiore Hospital. The treatment planned for this patient was intensive irradiation with

a few infiltrations and fluid at both bases (Fig. 6). The patient's condition regressed rapidly and he died ten weeks following the radiotherapy. At the postmortem examination, there was fixation and stenosis of the esophagus, but no evidence of carcinoma, fluid at both bases, post-irradiation changes in the heart and lungs.

Comment. Scar formation and contraction of the esophagus is not uncommon

TABLE II

Date	Field	Size	Dose	Kv.	Ma.	Filter	Distance
May 1933 I	Ant. and post. mediastinum	10×15 cm.	1,600 r each	200	5	0.5 mm. Cu plus 1 mm. Al	50 cm.
10/27 1933- 1/6 1934 II	Ant. and post. mediastinum R. ant. and post. chest L. ant. and post. chest	12×8 cm. 12×8 cm. 12×8 cm.	2,650 r each 2,650 r each 2,650 r each	200	30	0.5 mm. Ag plus 1 mm. Al	50 cm.
3/29-5/18 1934 III	Same fields as in course II	12×8 cm.	2,000 r each	200	30	0.5 mm. Ag plus 1 mm. Al	50 cm.
9/17-11/23 1934 IV	L. ant. and post. chest R. ant. chest Post. mediastinum R. and L. lat chest	12×8 cm. 12×8 cm. 12×8 cm. 10×15 cm.	2,000 r each 2,000 r 2,000 r 2,000 r each	200	30	0.5 mm. Ag plus 1 mm. Al	50 cm

following intensive irradiation. Some of these patients may even require dilatation to eliminate dysphagia. It is very likely that the cancer in this patient was controlled by the second course of irradiation and that the difficulty in swallowing was due to scar formation. A second or third course of



FIG. 5. Case II. Obstruction and deformity in the lower third of the esophagus prior to the second course of irradiation.

treatment is rarely successful, providing the dosage with the initial irradiation is adequate. If dysphagia appears after well planned irradiation, an esophagoscopy should be performed and a biopsy taken of any suspicious area before any other treatment is considered. It should be borne in mind that previous radiotherapy, although no visible injury resulted with earlier series, can be the basis for later damage, if subsequent treatment is not given with great caution.

Patients with Pulmonary or Mediastinal Tuberculosis Are Apt To Do Badly with Intensive Irradiation.



FIG. 6. Case II. Atelectasis both lower lobes, a few infiltrations and fluid at both bases six weeks following fourth course of irradiation.

TABLE III

Date	Field	Size	Dose	Kv.	Ma.	Filter	Distance
1/27-2/28	R. ant. and post. mediastinum	14×17 cm.	2,000 r each	198	30	0.5 mm.	60 cm.
1936	L. ant. and post. mediastinum	14×17 cm.	2,000 r each			Cu plus 1 mm. Al	

CASE III. (Montefiore Hospital No. 28028) M. G., male, aged sixty-two.

A case of carcinoma of the esophagus, upper and middle thirds, in a man with inactive pulmonary tuberculosis. The sputum had been negative for six years. The biopsy showed degenerating squamous cell carcinoma. A gastrostomy had been performed prior to his admission to Montefiore Hospital. The roentgen therapy this patient received was given at another institution (Table III). The daily dose was 300 r/o over one field. The tumor received approximately 3,670 r over a period of twenty-eight days. General condition of the patient was fairly good for about one year following irradiation. There was onset then of dry nocturnal cough and dyspnea on exertion. Three months later hemorrhage, pain in the chest, cyanosis, dyspnea, and a rise in temperature came on suddenly. This episode was believed due to bronchial erosion. The next day, the patient developed signs of a bronchopneumonia. A sputum exami-

nation was positive for tubercle bacilli. The patient suddenly developed Cheyne-Stokes respiration and died. Roentgenograms of the chest on admission (nine months following irradiation) showed fibrotic infiltrations in both apices and infraclavicular regions and rather marked fibrosis in the medial portions of the lungs (Fig. 7). In the following year, pulmonary fibrosis became more marked in the medial portions of the lungs (Fig. 8). The postmortem examination showed no carcinoma in the esophagus. Extensive irradiation fibrosis was observed in the medial portions of the lungs with matting together by fibrosis of trachea, bronchi and aorta in the region of the tracheal bifurcation. Bilateral healed pulmonary tuberculosis was present in the apices. In the hilar region, the lymph nodes were tuberculous. The parietal pericardium was firmly adherent on both sides to the pleura.

Comment. The pulmonary damage this



FIG. 7. Case III. Fibrotic tuberculous infiltrations in both apices and infraclavicular regions and rather marked fibrosis in the medial portions of the lungs on admission, three months following irradiation.



FIG. 8. Case III. Marked increase in the fibrosis in the mediastinum and medial portions of the lungs, nine months following irradiation.

patient sustained unquestionably led to his death. The radiation dose of 10,800 r that he received over a period of thirty-two days is, as a rule, well tolerated by the average patient. When damage to the lungs does occur with this dosage, the injury is slight and gives few symptoms. Undoubtedly, the tuberculous nodes in the hilar regions were a factor in the severe damage that ensued. Toxins may have been liberated by the infected hilar glands, which may have sensitized the lungs and mediastinum, with the resultant abnormal reaction to the irradiation trauma. It is interesting to note that although the tumor dose was rather low, about 3,679 r, no carcinoma was found in the esophagus at the postmortem examination.

Perforation Complicating Fractionated Roentgen Therapy of Moderate Dosage.

died with symptoms of bronchopneumonia. The postmortem examination showed an extensive area of ulceration in the upper and middle thirds of the esophagus, with perforation into the posterior mediastinum, mediastinitis, pleuritis, and bronchopneumonia in the right lower lobe. The microscopic examination of the tissue from the esophagus showed only a few tumor cells undergoing degeneration.

Comment. Perforation with resulting mediastinitis is a not uncommon complication of esophageal carcinoma, even in patients who have not been irradiated. In this instance, the irradiation probably brought on the perforation more rapidly.

RESULTS OF TREATMENT

The material to be presented consists of 13 cases, 3 of carcinoma in the upper third of the esophagus, 5 in the middle third, and

TABLE IV

Date	Field	Size	Dose	Kv.	Ma.	Filter	Distance
2/27-3/28	R. and L. ant. mediastinum	6×17 cm.	1,750 r each	200	30	0.5 mm.	50 cm.
1936	R. and L. post. mediastinum	7×17 cm.	1,500 r each	200	30	Ag plus 1 mm. Al	50 cm.

CASE IV. (Montefiore Hospital No. 26421) L. L., female, aged fifty-four.

A patient with carcinoma of the esophagus, middle third, of twelve months' duration when admitted to Montefiore Hospital. Biopsy at another institution showed squamous cell carcinoma, Grade 2. Four months prior to her admission, she received elsewhere a total of fourteen roentgen treatments, each 300 r/o, to two anterior and two posterior portals for a total of 4,200 r. The patient's improvement was very slight and the irradiation was interrupted to do a gastrostomy. Roentgen therapy was again instituted upon her admission to Montefiore Hospital, three months later. She received a total of 6,500 r to two anterior and two posterior portals in a period of twenty-nine days (Table IV). The individual doses were 250 r/o. The irradiation was discontinued because of increased pain in the chest, weakness and poor general condition. The next day the patient's temperature and pulse rose and stayed elevated for about a week, when she

5 in the lower third. Five of these patients were women. With the exception of one patient, with involvement in the upper third, who had intracavitary radium therapy just before death, the cases were treated solely with roentgen radiation. The results of the radiation are noted in Table V. They show a considerable increase in life expectancy after the onset of symptoms, as compared to the five to eight months quoted in the literature for non-treated patients.¹⁰

Montefiore Hospital is an institution for the treatment of chronic diseases and, as a rule, the cases of carcinoma admitted are in the advanced stages of their ailment. Of the patients with carcinoma in the upper third, 2 were in the terminal stages of their disease and showed very extensive lesions at the postmortem examinations. The third patient died of a tracheo-esophageal fistula

TABLE V
RESULTS OF RADIATION THERAPY IN THIRTEEN PATIENTS
WITH CARCINOMA OF THE ESOPHAGUS

	Upper Third	Middle Third	Lower Third	Total
No. of cases	3	5	5	13
No. dead	3	5	5	13
Average time from onset of symptoms to death in months	13.3	15	24.5	
Average time from treatment to death in months	7.1	10.7	17.5	11
No. alive	0	0	0	0

after intracavitary radium. He was markedly improved following adequate roentgen therapy, and was given the radium for recurring difficulty in swallowing. A biopsy prior to the radium treatment was negative. No carcinoma was found at the postmortem examination. Of the 5 patients with carcinoma in the middle third, the poorest result was obtained in Case IV, who died of a mediastinitis while being given a second course of irradiation. At the postmortem examination, the only evidence of malignancy were a few tumor cells undergoing degeneration. Death was due to the complicating mediastinitis. From reports in the literature, radiotherapy gives the poorest results for carcinoma in the lower third. This does not hold true for the cases reported by Smithers and by myself. In our group, the histopathologic diagnosis in all cases was squamous cell carcinoma. One patient, a female, aged forty-five, with an anaplastic lesion, lived twenty-seven months following irradiation. The average for the group would have been higher were it not for one case with far advanced malignancy who lived only one month following roentgen treatment. Another patient, Case II, showed no evidence of carcinoma at the postmortem examination. In all, 3 patients, of all those treated, who had autopsies performed, showed no evidence of carcinoma, and in a fourth case, only a few degenerat-

ing malignant cells were found. The immediate response to irradiation was good in most instances. With the partial or complete temporary disappearance of the tumor, swallowing was improved and this was followed by improved general condition. Many of the patients did not require a gastrostomy. Death was often due to secondary complications or to metastases. Our results with radiation therapy at the Montefiore Hospital, plus the findings already cited in the literature, are ample proof of the value of irradiation as a palliative procedure in carcinoma of the esophagus.

Although we have no case of carcinoma of the esophagus controlled for five years or more at the Montefiore Hospital, I have one such case treated privately. This patient is reported in detail to show what can be accomplished with roentgen therapy in some instances, if radiotherapy is instituted in the early stages of the disease.

CASE V. B. S., male, aged forty-nine.

Case of epidermoid carcinoma of the middle third of the esophagus, Grade 3, of six months' duration (Fig. 9). The treatment was carried out according to the principles laid down under Method of Irradiation. Three adjacent anterior and three similar posterior portals were utilized. The size of each varied from 6 by 12 cm. to 6 by 15 cm. The patient was treated over two portals daily, but not with adjacent fields,

TABLE VI

Date	Field	Size	Dose	Kv.	Ma.	Filter	Distance
9/25-11/2 1939	Ant. mediastinum	6×14 cm.	2,950 r	200	8	0.5 mm. Cu plus 1 mm. Al	70 cm.
	Post. mediastinum	6×15 cm.	2,825 r	200	8	0.5 mm. Cu plus 1 mm. Al	70 cm.
	Ant. L. oblique	6×15 cm.	2,750 r	200	8	0.5 mm. Cu plus 1 mm. Al	70 cm.
	Ant. R. oblique	6×15 cm.	2,700 r	200	8	0.5 mm. Cu plus 1 mm. Al	70 cm.
	Post. R. and L. oblique	6×15 cm.	2,700 r each	200	8	0.5 mm. Cu plus 1 mm. Al	70 cm.

to avoid excessive irradiation of a particular region of the lung; for example, when the patient was irradiated from the left anterolateral portal, the second field would be the right posterolateral portal; central anterior and central posterior fields, etc. The surface dosage was calculated to give the tumor from 150 to 200 r daily. The tumor dose was occasionally lowered if the patient had a severe reaction the previous day. The daily surface dose was, as a rule, 500 to 600 r/o, 250 to 300 r/o per portal. The other factors were 200 kv., 8 ma., filter 0.5 mm. Cu plus 1 mm. Al (plus inherent filter of 3 mm. Al), target skin distance 70 cm. The patient received a minimal tumor dose of 5,500 r, over a period of thirty-eight days. He was ambulant, and

working during the entire period of irradiation. Radiation sickness was controlled by intramuscular injections of vitamin B₁. Dysphagia was present during the period of irradiation, and the patient had to be maintained on liquids, but his weight loss for this period was only 3 pounds. About a week following completion of the irradiation, there was onset of temperature up to 102.5° F., mediastinal pain, general malaise, and later, cough. The patient was ill with respiratory symptoms for about one month, but swallowing was markedly improved. Roentgenograms of the chest and esophagus, seven weeks following irradiation, showed infiltrations in the hilar regions simulating mild irradiation pneumonitis (Fig. 10). The esophagus was negative,



FIG. 9. Case v. Deformity in the middle third of the esophagus due to carcinoma.

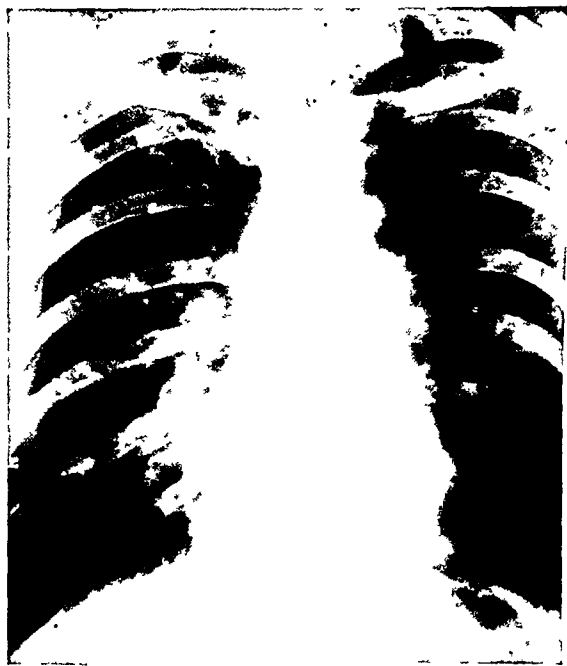


FIG. 10. Case v. Infiltrations in the hilar regions due to mild irradiation pneumonitis seven weeks following irradiation.

except for a slight constriction at the site of the neoplasm (Fig. 11). Seven months after irradiation the patient was again esophagoscopied because he complained of occasional difficulty in swallowing solids, localized to the site of the irradiation. The esophagus was negative except for a slight constriction about 20 cm. from the upper incisors. On the right side, there was a soft web-like mucosa, which appeared part of a fibrotic process. The patient is well to date, with no evidence of recurrence or metastases, a period of seven years and seven months since the irradiation. The successful treatment can probably be attributed to the following factors. The carcinoma was localized, papillary in type, radiosensitive, Group III, the diameter of the chest at the site of the growth was only 19 cm., thus the depth dosage was relatively high, the daily and total tumor dose was adequate, and finally, the treatment period was not unduly long (thirty-eight days).

CONCLUSION

Present methods of treatment of carcinoma of the esophagus have been re-evaluated. Factors governing the response of esophageal carcinoma to irradiation are enumerated. Our experiences at Montefiore Hospital with radiation treatment for this ailment are reported. Survival in months appears to have been increased for those patients who were treated. Of four patients who had autopsies performed, some time after irradiation, three showed no evidence of carcinoma, and in the fourth case, only a few degenerating carcinoma cells were found. One patient from the author's private practice is living and well, seven years and seven months following irradiation. Complications which are associated with this intensive irradiation, are discussed.

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REFERENCES

1. ADAMS, W. E., and PHEMISTER, D. B. Carcinoma of the lower thoracic esophagus. *J. Thoracic Surg.*, 1938, 7, 621-632.
2. BAUM, S. M. Esophageal-gastric carcinoma successfully treated by protracted fractional x-ray. *Radiology*, 1936, 27, 58-62.
3. BRITISH CLINICAL CANCER RESEARCH COMMITTEE. Annual Report, 1942. Esophageal and



FIG. 11. Case v. Esophagus negative except for slight constriction in the posterior wall at the site of the carcinoma seven weeks following irradiation. This appearance has remained unchanged to the present, seven years two months following treatment.

- Post Cricoid Carcinoma. Year Book of Radiology. Year Book Publishers, Chicago, 1944, pp. 394-395.
4. BRODERS, A. C., and VINSON, P. P. Degree of malignancy of carcinoma of esophagus. *Arch. Otolaryng.*, 1928, 8, 79-80.
5. BRUNN, H., and STEPHENS, H. B. Carcinoma of the thoracic esophagus. *J. Thoracic Surg.*, 1937, 7, 38-42.
6. BUSCHKE, F., and CANTRIL, S. T. Supervoltage roentgen therapy of esophageal carcinoma. *Radiology*, 1944, 42, 480-492.
7. GARLOCK, J. H. Surgical treatment of carcinoma of the thoracic esophagus. *Surg., Gynec. & Obst.*, 1940, 70, 556-569.
8. GUISEZ, J. Les causes de réussite ou d'échec dans la radiumthérapie du cancer de l'esophage. *Ann. d'oto-laryng.*, 1932, 2, 1028-1041.
9. HOLMES, G. W., and SCHULZ, M. D. Supervoltage radiation; review of cases treated during an eight year period (1937-1944 inclusive). *AM. J. ROENTGENOL. & RAD. THERAPY*, 1946, 55, 533-554.
10. HÜNERMANN, M., and EBERHARDT, O. Ueber den gegenwärtigen Stand der Diagnostik und

- Therapie des Oesophaguskarzinoms. *Monatsschr. f. Krebsbekämpfung*, 1938, 6, 177; 209.
11. KING, E. S. J. Oesophagectomy for carcinoma of the thoracic oesophagus. *Brit. J. Surg.*, 1936, 23, 521-529.
 12. LEVITT, W. M. Treatment of carcinoma of esophagus by new method of deep x-ray therapy. *St. Barth. Hosp. Rep.*, 1935, 68, 107-120.
 13. MAYNEORD, W. V. Optical device for accurate alignment of x-ray beam. *Brit. J. Radiol.*, 1939, 12, 257-258.
 14. NIELSEN, S. Klinische Versuche zur Strahlenbehandlung des Speiseröhrenkrebses. *Acta radiol.*, 1940, 21, 352-367.
 15. SMITHERS, D. W., CLARKSON, J. R., and STRONG, J. A. The roentgen treatment of cancer of the esophagus. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1943, 49, 606-634.
 16. STRANDQVIST, M. Transthoracic roentgen treatment of cancer of the oesophagus. *Acta radiol.*, 1941, 22, 172-193.
 17. TILLEY, H. Cancer of oesophagus treated by deep x-ray therapy; symptom-free nearly two years. *Brit. M. J.*, 1937, 1, 1199-1200.
 18. TOREK, F. First successful case of resection of thoracic portion of esophagus for carcinoma. *Surg., Gynec. & Obst.*, 1913, 16, 614-617.
 19. TOREK, F. Carcinoma of thoracic portion of esophagus. *Arch. Surg.*, 1925, 10, 353-360.
 20. WATSON, W. L. Carcinoma of oesophagus. *Surg., Gynec. & Obst.*, 1933, 56, 884-897.
 21. WATSON, W. L. Cancer of esophagus. *Connecticut M. J.*, 1942, 6, 959-961.
 22. WATSON, W. L. Cancer of cervical esophagus. *Ann. Surg.*, 1942, 116, 86-97.
 23. ZUPPINGER, A. Die Behandlung der Ösophaguskarzinome. *Ergebn. d. med. Strahlenforsch.*, 1936, 7, 389-456.



NEW TYPES OF FAST CAMERAS*

PAPER IV†

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DURING the war we investigated various types of fast cameras of wide field. Dr. Paul C. Hodges of The University of Chicago requested us, through the Committee on Medical Research and the National Defense Research Committee, to investigate the possible usefulness of the newly developed cameras in photofluorography. There has been a trend in astronomical photography away from the use of lens systems. Fast cameras are required in astronomical research since the light sources are faint. The photofluorographic problem is therefore a closely related one. Short focus lenses of focal ratio up to $f/1$ have been used but have many disadvantages. Fast lenses are thick, involving considerable absorption of light in the glass; the process of coating lenses to reduce internal reflection losses is not completely efficient. Further, the resolving power of lenses is usually quite low at large fields.

One of the natural defects of an optical system is the aberration called "curvature of field." This aberration must be eliminated if we are to cover a wide field on a flat film or plate. In this process, unfortunately, the lens designer must sacrifice many things—high speed and wide, flat field are almost incompatible. The recent design of fast systems has shown that if we abandon the requirement of flatness of field great advances can be made. If a system has a curved field, the images lie approximately on a spherical surface. After some experimentation Dr. Hodges has found that dependable film bending and feeding mechanisms can be developed; 35 mm. film can be bent to a radius of 2 inches and 70 mm. film to a 5 inch radius.

In the newer systems we employ a concave mirror to focus the light. Mirrors have substantial advantages over lenses; they are achromatic and have less spherical aberration, for a given focal ratio, than does a lens. Large mirrors can be manufactured cheaply. A material like pyrex can be used since the rays do not have to pass through the mirror. The front, concave surface is coated with a highly reflecting evaporated aluminum coat, which resists tarnishing for long periods of use, and can be easily recoated. A spherical mirror has spherical aberration and cannot be used alone to produce a sharp image. This aberration can be corrected by using either an aspheric correcting plate (the Schmidt camera) or spherical correcting lens (our new types).

The Schmidt camera has had a wide and successful application for scientific purposes. It possesses a curved field and can give as high resolution as is required at the center of the field. Schmidt cameras have been used in the range of speed $f/3.5$ to $f/0.7$. The correcting plate is a thin piece of glass with one side ground and polished to a shape which is described mathematically as a curve of the fourth degree. Such a curve cannot now be made commercially in quantity by machine with suitable precision, especially when very fast cameras are required. For relatively low resolving power the correctors can be molded in plastic; for high resolution each correcting plate requires extensive hand work by a skilled optician. A well-made Schmidt camera gives excellent images for small fields, but suffers from various defects when wide field (diameter greater than 10°) is combined with high speed (faster than $f/2$). An important advantage of the Schmidt cam-

* This research was done, in part, under Contract OEMsr-1078, with Division 16, Section 16.1 of the National Defense Research Committee. Related work is described in the declassified OSRD Report No. 4504, "Wide Field Fast Cameras."

† For Papers I, II and III in this series see AM. J. ROENTGENOL. & RAD. THERAPY, January, 1948, 59, 122-131; February, 1948, 59, 282-289; March, 1948, 59, 416-419.

era is that the light loss is very small. Only a thin glass plate and a mirror exist to reflect and absorb light. Furthermore, at wide fields the curvature of the image surface is an advantage. A flat film receives light at wide fields at a nearly grazing angle of incidence, while in the curved film the light enters more nearly perpendicularly. In the Schmidt, and in our new systems, the focal

and mirror combination can be manufactured in quantity with high precision.

A monocentric lens is in general negative, i.e. divergent. Used in combination with a mirror, however, we obtain a real focus located in front of the mirror and on a curved surface whose radius equals the equivalent focal length of the system. The negative lens would have chromatic aber-

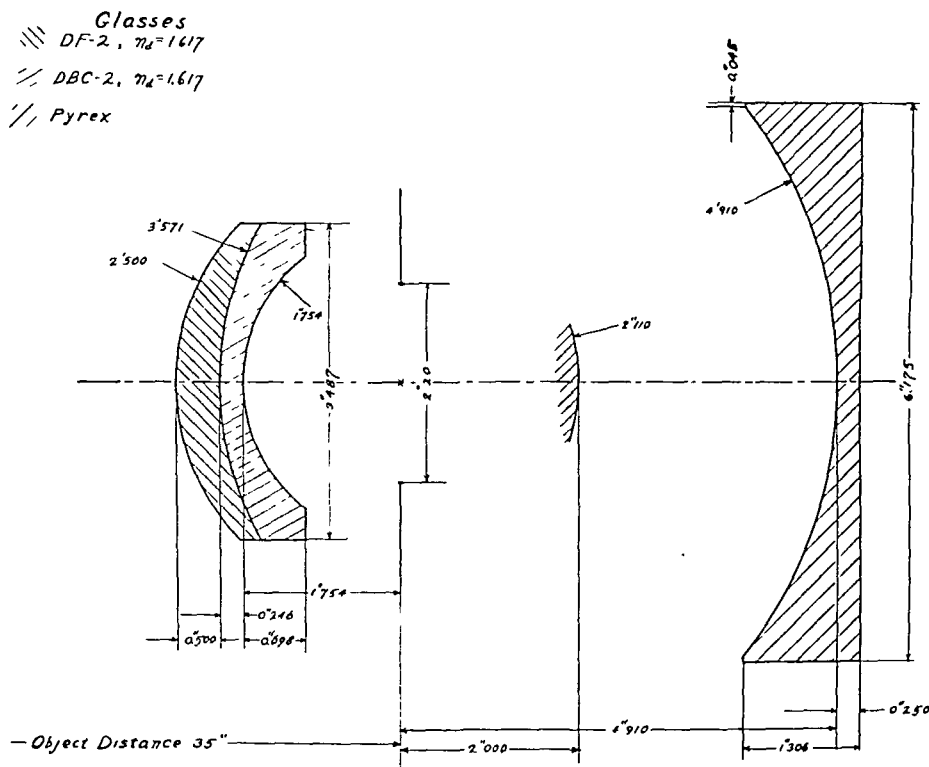


FIG. 1. Optical system for 35 mm. photofluorography. Speed (disregarding silhouetting) $f/0.91$.

plane lies between the object and the mirror i.e. "inside" the system.

We will call our new types of fast lens and mirror systems "monocentric." They have two essential features: (1) only spherical surfaces are used, and (2) all significant optical surfaces have a common center of curvature located at a diaphragm which limits the entering rays. Brief consideration shows that such a system has a spherical symmetry which guarantees an indefinitely large field of view if we can obtain satisfactory definition on axis. Since only spherical surfaces are involved such a lens

ration if made of a single piece of glass. As will be seen in Figures 1 and 2 we make the lens a doublet. The glasses are chosen such that their indices of refraction are the same at one color, but differ enough at other colors to correct the on-axis chromatic aberration completely. A residual chromatic aberration appears at large field angles, but is negligible in practice with the fluorographic screens and films now in use. The chromatic correction must be made for that range of color present in the fluorescing screen to which the films are sensitive. We have found that systems of the type shown

in Figure 1 can be designed and made satisfactorily up to focal ratios $f/0.9$, and that the more recently developed type shown in Figure 2 attains $f/0.62$. Lens systems with sufficient field of view and resolution have not yet been made to rival these speeds.

The following formula is to be used to

The focal ratio is simply

$$\frac{\text{E.F.L.}}{\text{Aperture of Diaphragm}}$$

The light-gathering power is proportional to the square of the numerical aperture

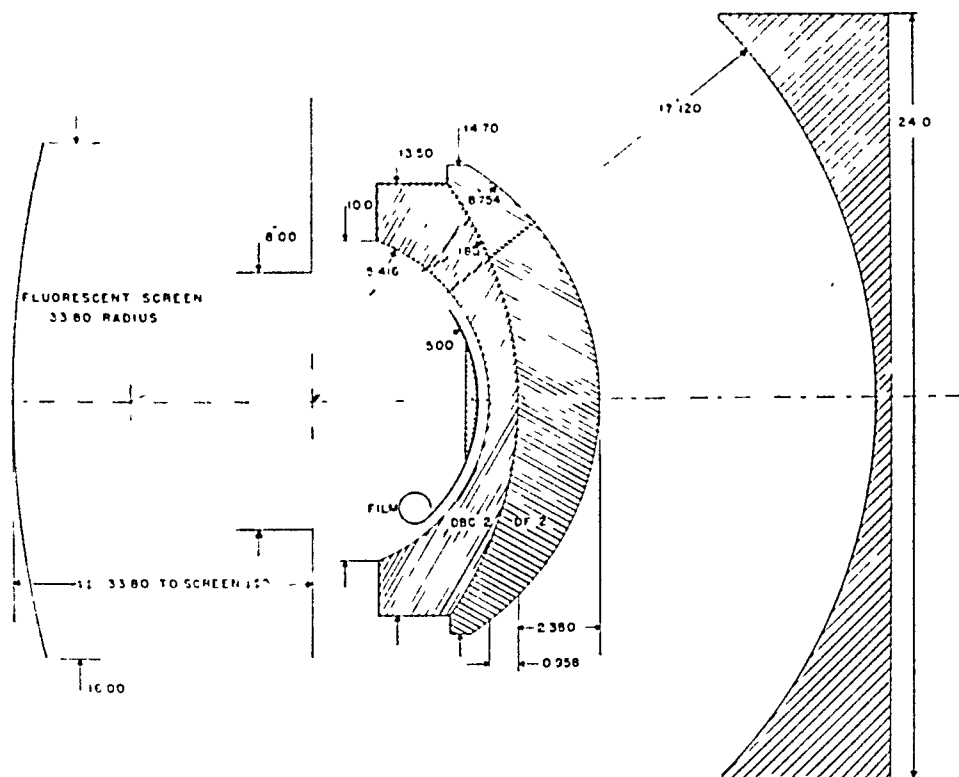


FIG. 2. Optical system for 70 mm. photofluorography. Speed (disregarding silhouetting) $f/0.62$.

determine the equivalent focal length (E.F.L.) of the camera in order to satisfy the geometrical requirements:

$$\text{E.F.L.} = \frac{\text{Image Size} \times \text{Screen Distance}}{\text{Screen Size}}$$

The light-gathering power of a camera is measured by its numerical aperture (N.A.) or by its focal ratio. The first of these is given by the formula

$$\text{N.A.} = \sin U,$$

where U is half of the angular aperture of the light bundle falling on each point of the focal surface. In a well corrected optical instrument we also have the relationship

$$\text{N.A.} = \frac{\text{Aperture of Diaphragm}}{2 \times \text{E.F.L.}}$$

or inversely to the square of the focal ratio. This supposes that there are no light losses in the camera which, unfortunately, is not true.

When the numerical aperture is large the outer rays in the light bundle strike the photographic film at large angles and tend to be more strongly reflected by the film than rays incident more normally. The result is that in practice the effective speed varies more slowly than that given by the square of the numerical aperture when the latter approaches values near unity.

Absorption in the glass forming the lenses, loss of light by reflection at the surfaces of the lenses and imperfect reflectivity of reflecting surfaces constitute an important loss of speed in all cameras. At an ordinary air-glass refracting surface the reflection

loss is never less than 4 per cent and is usually more than this, averaging perhaps 7 per cent. The application of antireflection coats to such surfaces serves to cut these losses by two- or three-fold leading to significant gains in complex systems containing many refracting surfaces. The loss at a good reflecting mirror surface is about 10 per cent.

In cameras utilizing a mirror another loss of speed arises from the obscuration caused by the mechanism supporting the photographic surface in place. Owing to reversal in direction, the light must traverse the region containing the focus prior to being reflected. The manner in which this effect takes its toll may be understood by examining the two drawings.

The effective speed, allowing for the obscuration, is conveniently represented by specifying the numerical aperture or the focal ratio of a camera of identical focal length having an aperture whose area is equal to the unobscured area of the actual camera. This area can be estimated from that seen unobscured when the eye is placed at the source.

The optical layout of the system designed for and now in operation at the Division of Roentgenology of The University of Chicago is shown in Figure 1. Light coming from the screen (from the left) traverses a doublet lens, is limited by a diaphragm, and after reflection from a concave aluminized mirror is focussed on the curved film, which faces the mirror. The geometrical speed is $f/0.91$ (N. A. 0.55), the field is 40° in diameter and the equivalent focal length,* 2 inches. Standard 35 mm. film is used. All glass-air surfaces have radii with a common center located at the diaphragm. The mechanical and electrical details of the camera will be described by Dr. Paul C. Hodges. The theoretical resolving power is near 40 lines per millimeter, and in

practice the over-all resolution of camera, film and screen is about 30 lines per millimeter.* The film-feed mechanism was made compact to avoid unnecessary obscuration of the light reaching the film. The effective speed is equivalent to $f/1.15$ (N. A. 0.43) since the camera requires about 60 per cent of the exposure of a standard $f/1.5$ (N. A. 0.33) lens.

A much larger and faster camera has been designed and will be constructed to handle 70 mm. film. If the screen size and distance are the same, the equivalent focal length must be larger to obtain the larger picture and after some experimentation Dr. Hodges chose a 5 inch focal length. The problem of bending large films to a steeper radius of curvature dictates this choice and requires that the optical parts be much increased in size. The fundamentally new feature of this monocentric system is that the spherical correcting lens is traversed twice by the light on its way from the diaphragm to the mirror and then back to the film. We are thus able to correct the spherical aberration to a higher order of accuracy and to reach a speed of $f/0.62$ (N. A. 0.8). Owing to the extreme speed of this device it is necessary to curve the fluorescing screen into a sphere concentric with the optical surfaces. It is not possible here to take up the flatness of the screen by altering the radius of the focal surface, without introducing intolerably poor definition in the outer portions of the field. The layout is shown in Figure 2, for $f/0.62$ (N. A. 0.8) and a field 26° in diameter. The effective speed of the system has not yet been determined experimentally but we hope that it will be close to $f/0.75$ (N. A. 0.67) and that the required exposure times will be only one-quarter of those with a conventional $f/1.5$ lens (N. A. 0.33) and four-tenths of those with the monocentric camera already constructed. The resolving power of the camera alone is estimated to be nearly 20 lines per millimeter.

It should be noted that the two cameras described are typical of a larger class which

* It will be seen that the radius of the focal surface is not exactly equal to the focal length. The difference arises because of the flatness of the fluorescing screen. If it were curved with a radius equal to the object distance, 35 inches in this case, the radius of the focal surface would equal the equivalent focal length.

* Equivalent to about two lines per millimeter at the surface of the fluorescent screen.

can be constructed for any required application. The distance screen to camera can be changed and the nature of the achromatization altered if screens different from the Type B fluoroscopic screen are used. The focal lengths can be changed by scaling all lengths and apertures in the system in proportion. Minor changes in radii may be required, but the fundamental design remains the same. The $f/0.62$ camera might possibly

be used with 35 mm. film, by such a scaling, but unfortunately the clearance between the focal surface and the lens becomes so small that the mechanical design of the film-bending mechanism will be difficult. At present we see no immediate prospect of designing cameras faster than $f/0.62$ without using aspheric surfaces.

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Publisher: CHARLES C THOMAS, 301-327 East Lawrence Avenue, Springfield, Illinois.

Issued Monthly. Subscription \$10.00 per year, \$11.00 in Canada and \$12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 301-327 East Lawrence Avenue, Springfield, Ill. Information of interest to all readers will be found on page vi.

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Thirtieth Annual Meeting: Stevens Hotel, Chicago, Ill., June, 20-22, 1948.

EDITORIAL

ANNUAL MEETING OF THE AMERICAN RADIUM SOCIETY

AT THE Thirtieth Annual Meeting of the American Radium Society to be held at the Hotel Stevens, Chicago, Illinois, June 20-22, 1948, there will be celebrated the semicentennial of the discovery of radium. The keynote of the meeting is given by the title of the Janeway Lecture: "The Achievement of Radium in the Fight Against Cancer" by Sir Stanford Cade. Although the value of radiotherapy of cancer is supported by world-wide statistics of cured patients observed for five or more years after treatment, a tendency has recently developed in the United States to forget these results and substitute radical surgery for radiotherapy. The revival of radical surgery has been facilitated by the development of newer methods of combating shock and infection. As yet there is no assurance, however, that these initial surgical successes will yield a high proportion of five year cures. At the meeting of the American Radium Society the accomplishments of radiotherapy in various types of cancer will be dealt with in separate papers, while end-results in cancer of the tongue and of the breast after treatment by surgery and radiation will be considered in panel discussions.

During the recent war years it was difficult to keep in touch with the progress of radiotherapy in Europe. In addition to the members of the American Radium Society and other representatives of American radiotherapy, a number of distinguished guests from England, France and Sweden have been invited to participate in the forthcoming meeting. Those who have signified their acceptance are:

François Baclesse, Director of Roentgen Therapy, Curie Foundation, Paris

Juliette Baud, Director of Radium Therapy, Curie Foundation, Paris

Elis Berven, Professor of Radiotherapy, Uni-

versity of Stockholm, and Director of Radiumhemmet, Stockholm

Sir Stanford Cade, Surgeon, Westminster and Mount Vernon Hospitals and Radium Institute London

Paul Lamarque, Professor of Radiology, University of Montpellier, France

Robert McWhirter, Royal Infirmary, Edinburgh, Scotland

B. W. Windeyer, Professor of Radiotherapy, University of London, and Director of Meyerstein Institute of Radiotherapy, Middlesex Hospital, London

Constance Wood, Director of Radiotherapy Research Unit (Radium Beam) of the Medical Research Council, London, England

While radiotherapy of cancer in hospitals in the United States is carried out for the most part in general radiological departments, radiotherapy and roentgen diagnosis are completely divorced in England. There is a separate qualifying Board of Radiotherapy and another for Roentgen Diagnosis. Radiotherapy has made great strides in England since this separation. Some of the most important advances in radiotherapy of cancer in the past have been made at the Curie Foundation in Paris and at the Radiumhemmet in Stockholm, which were founded primarily for this purpose "Should Radiotherapy be Separated from Roentgen Diagnosis?" is the topic of one of the panel discussions to be held at the meeting. Foreign and American authors will participate.

Seven Refresher Courses will be given by the foreign guests at which there will be opportunity to ask questions and discuss the authors' views informally. Registration for the Refresher Courses and the meeting will start on Saturday, June 19, 1948. Elsewhere in this issue will be found the Preliminary Program of the meeting.

MAURICE LENZ, M.D.

840 Park Ave.
New York 21, N. Y.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY

Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Palmer House, Chicago, Ill., Sept. 14-17, 1948.

AMERICAN RADIUM SOCIETY

Secretary, Dr. H. F. Hare, 605 Commonwealth Ave., Boston, Mass. Annual meeting: Stevens Hotel, Chicago, Ill., June 20-22, 1948.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1948, to be announced.

AMERICAN COLLEGE OF RADIOLOGY

Secretary, Mac F. Cahal, 20 N. Wacker Drive, Chicago 6. Annual meeting: Continental Hotel, Chicago, Ill., June 20, 1948.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION

Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: Chicago, Ill., June 21-25, 1948.

ALABAMA RADIOLOGICAL SOCIETY

Secretary, Dr. C. S. Stickley, 515 Bell Bldg., Montgomery, Ala. Next meeting time and place of Alabama State Medical Association.

ARKANSAS RADIOLOGICAL SOCIETY

Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

BROOKLYN ROENTGEN RAY SOCIETY

Secretary, Dr. A. H. Levy, 1354 Carroll St., Brooklyn 13, N. Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY

Secretary, Dr. Mario C. Gian, 610 Niagara St., Buffalo, N. Y. Meets second Monday evening each month, October to May inclusive.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY

Secretary, Dr. Dwight V. Needham, 608 E. Genesee St., Syracuse, N. Y. Three meetings a year. January, May, November.

CHICAGO ROENTGEN SOCIETY

Secretary, Dr. T. J. Wachowski, 310 Ellis Ave., Wheaton, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY

Secretary, Dr. Eugene L. Saenger, 735 Doctors Bldg., Cincinnati 2, Ohio. Meets last Monday of each month, September to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY

Secretary, Dr. George L. Sackett, 10515 Carnegie Ave. Cleveland 6, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

DALLAS-FORT WORTH ROENTGEN STUDY CLUB

Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

DENVER RADIOLOGICAL CLUB

Secretary, Dr. Mark S. Donovan, 306 Majestic Bldg., Denver 2, Colo. Meets third Friday of each month at Department of Radiology, Colorado School of Medicine.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY

Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA RADIOLOGICAL SOCIETY

Secretary, Dr. J. A. Beals, St. Luke's Hospital, Jacksonville, Fla. Meets twice yearly, in April preceding annual meeting of Florida Medical Society, and in November.

GEORGIA RADIOLOGICAL SOCIETY

Secretary, Dr. Robert Drane, DeRenne Apartments, Savannah, Ga. Meets in mid-winter and at annual meeting of Medical Association of Georgia in the spring.

HOUSTON X-RAY CLUB

Secretary, Dr. Curtis H. Burge, 3020 San Jacinto St., Houston 4, Texas. Meetings fourth Monday of each month.

RADIOLOGICAL SOCIETY OF KANSAS CITY

Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

ILLINOIS RADIOLOGICAL SOCIETY

Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY

Secretary, Dr. J. A. Campbell, Indiana University Hospitals, Indianapolis 7. Meets second Sunday in May.

IOWA X-RAY CLUB

Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

KENTUCKY RADIOLOGICAL SOCIETY

Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY

Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOS ANGELES RADIOLOGICAL SOCIETY

Secretary, Dr. Moris Horwitz, 441 No. Camden Drive, Beverly Hills, Calif. Meets second Wednesday each month at Los Angeles County Medical Assn. Building.

LOUISIANA RADIOLOGICAL SOCIETY

Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

LOUISVILLE RADIOLOGICAL SOCIETY

Secretary, Dr. E. L. Pirkey, Louisville General Hospital, Louisville 2, Ky. Meets monthly on second Friday at Louisville General Hospital.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS

Secretary, Dr. R. D. McDuff, 220 Genesee Bank Bldg., Flint 3, Mich.

MILWAUKEE ROENTGEN RAY SOCIETY

Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

* Secretaries of societies not here listed are requested to send the necessary information to the Editor.

MINNESOTA RADIOLOGICAL SOCIETY

Secretary, Dr. Chauncey N. Borman, 802 Medical Arts Bldg., Minneapolis 2, Minn. Two meetings yearly, one at time of Minnesota State Medical Association the other in the fall.

NEBRASKA RADIOLOGICAL SOCIETY

Secretary, Dr. Ralph C. Moore, Nebraska Methodist Hospital, Omaha 3, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

NEW HAMPSHIRE ROENTGEN RAY SOCIETY

Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

NEW YORK ROENTGEN SOCIETY

Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

NORTH CAROLINA RADIOLOGICAL SOCIETY

Secretary, Dr. J. E. Hemphill, 323 Professional Bldg., Charlotte 2, N. C. Meets in May and October.

NORTH DAKOTA RADIOLOGICAL SOCIETY

Secretary, Dr. C. O. Heilman, 807 Broadway, Fargo. Meetings held by announcement.

OHIO STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Carroll C. Dundon, 2065 Adelbert Road, Cleveland 6, Ohio. Next meeting at annual meeting of Ohio State Medical Association, Cincinnati, Ohio, March 31, 1948.

OKLAHOMA STATE RADIOLOGICAL SOCIETY

Secretary, Dr. P. E. Russo, 230 Osler Bldg., Oklahoma City, Okla. Three regular meetings annually.

OREGON RADIOLOGICAL SOCIETY

Secretary, Dr. William Y. Burton, 242 Medical Arts Bldg., Portland 5, Oregon. Meets monthly 2nd Wednesday, 8:00 P.M., Library of University of Oregon Medical School.

ORLEANS PARISH RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY

Secretary, Dr. S. J. Hawley, 1320 Madison St., Seattle 4, Wash. Meets annually in May.

PACIFIC ROENTGEN SOCIETY

Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY

Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport. Annual meeting, May 21-22, 1948, Erie, Pa., at Hotel Lawrence.

PHILADELPHIA ROENTGEN RAY SOCIETY

Secretary, Dr. Arthur Finkelstein, Graduate Hospital, 19th and Lombard St. Meets first Thursday each month October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY

Secretary, Dr. R. P. Meader, 4002 Jenkins Arcade Pittsburgh 22, Pa. Meets 6:30 P.M. at Webster Hall Hotel on second Wednesday each month, October to May inclusive.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY

Secretary, Dr. Harry A. Miller, 2452 Eutaw Place, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY

Secretary, Dr. Robert M. Lowman, Grace-New Haven Community Hospital, New Haven 11, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

RADIOLOGICAL SOCIETY OF NEW JERSEY

Secretary, Dr. Raphael Pomeranz, 31 Lincoln Park, Newark, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.

Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

Secretary, Dr. Maurice D. Frazer, 1037 Stuart Bldg., Lincoln, Nebr. Meets in Salt Lake City, Utah, 1948.

ST. LOUIS SOCIETY OF RADIOLOGISTS

Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September.

SAN DIEGO ROENTGEN SOCIETY

Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly, first Wednesday at dinner.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION

Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY

Secretary, Dr. John H. Gilmore, 720 N. Michigan Ave., Chicago 11, Ill.

SHREVEPORT RADIOLOGICAL CLUB

Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

SOUTH CAROLINA X-RAY SOCIETY

Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY

Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY

Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING

Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE

Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May inclusive. Room 203, Service Memorial Institute, 426 N. Charter St., Madison.

UTAH RADIOLOGICAL CONFERENCE

Secretary, Dr. Henry H. Lerner, School of Medicine, University of Utah, Salt Lake City 1. Meets 1st and 3rd Thursdays monthly from 7:30 to 10 P.M., Salt Lake County General Hospital, September to June.

UTAH STATE RADIOLOGICAL SOCIETY

Secretary, Dr. M. Lowry Allen, Judge Bldg., Salt Lake City 1, Utah. Meets third Wednesday in September, November, January, March and May.

VIRGINIA RADIOLOGICAL SOCIETY

Secretary, Dr. P. B. Parsons, Norfolk General Hospital, Norfolk, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Homer V. Hartzell, 310 Stimson Bldg., Seattle 1, Wash. Meets fourth Monday each month, October through May, College Club, Seattle.

X-RAY STUDY CLUB OF SAN FRANCISCO

Secretary, Dr. Ivan J. Miller, 2000 Van Ness Ave. Meets monthly on third Thursday at 7:45 P.M., first six months of year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

CUBA**SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA**

President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

MEXICO**SOCIEDAD MEXICANA DE RADIOLOGIA Y FISIOTERAPIA**

General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

BRITISH EMPIRE**BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE ROENTGEN SOCIETY**

Medical Members' meeting held monthly on third Friday at 2:30 P.M. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

FACULTY OF RADIOLOGISTS

Secretary, Dr. M. H. Jupe, 23 Welbeck St., London, W.1 England.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)

Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London.

CANADIAN ASSOCIATION OF RADIOLOGISTS

Honorary Secretary, Dr. E. M. Crawford, 2100 Marlowe Ave., Montreal 28, Que. Meetings January and June.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION

Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

SOCIÉTÉ CANADIENNE-FRANÇAISE D'ELECTROLOGIE ET DE RADIOLOGIE MÉDICALES

Secretary, Dr. Origène Dufresne, 4120 Ontario St., East, Montreal, P. Q.

AUSTRALIAN AND NEW ZEALAND ASSOCIATION OF RADIOLOGISTS

Honorary Secretary, Dr. Alan R. Colwell, 135 Macquarie St., Sydney, N.S.W.

Honorary Secretaries, State Branches:

New South Wales, Dr. E. W. Frecker, 135 Macquarie St., Sydney.

Victoria, Dr. T. L. Tyrer, 3 Lockerbie Court, East St. Kilda.

Queensland, Dr. J. Adam, 131 Wickham Terrace, Brisbane.

South Australia, Dr. B. C. Smeaton, 178 North Terrace, Adelaide.

Western Australia, Dr. A. M. Nelson, 179-B St. Georges Terrace, Perth.

New Zealand, Dr. E. G. Lynch, 12 Bolton St., Wellington.

SOUTH AMERICA**SOCIEDAD ARGENTINA DE RADIOLOGIA**

Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

SOCIEDADE BRASILEIRA DE RADIOLOGIA MEDICA

Secretary, Dr. Nicola Caminha, Av. Mem de Sá, Rio de Janeiro, Brazil. Meets monthly, except during January, February and March.

SOCIEDADE BRASILEIRA DE RADIOTERAPIA

Secretary, Dr. Andreilino Amaral, Av. Brigadeiro Luiz Antonio, 644, São Paulo, Brazil. Meets monthly on second Tuesday at 9 P.M. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

SOCIEDAD PERUANA DE RADIOLOGIA

Secretary, Dr. Julio Bedoya Paredes, Apartado, 2306 Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

CONTINENTAL EUROPE**SOCIÉTÉ BELGE DE RADIOLOGIE**

General Secretary, Dr. S. Masy, 111 Avenue des Alliés, Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.

CESKOSLOVENSKÁ SPOLEČNOST PRO RÖNTGENOLOGII A RADIOLOGII V PRAZE

Secretary, Dr. Roman Bláha, Praha XII, stát. nemocnice, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.

POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. L. Zgliczynski, 59 Nowogrodzka St., Warsaw, Poland. Next meeting May 13 and 14, 1948.

GDANSK SECTION, POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. A. Smigielska, Akademia Lekarska, Gdansk. Meets monthly last Sunday at 10.30, X-Ray Dept., Akademia Gdansk.

WARSAW SECTION, POLISH SOCIETY OF RADIOLOGY

Secretary, Dr. L. Zgliczynski, 59 Nowogrodzka St., Warsaw, Poland. Meets monthly.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE

Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD. USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.

Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY

Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY

Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

SCANDINAVIAN ROENTGEN SOCIETIES

The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

SOCIEDAD ESPANOLA DE RADIOLOGIA Y ELECTROLOGIA

Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT (SOCIÉTÉ SUISSE DE RADIOLOGIE)

President, Dr. H. E. Walther, Gloristr. 14, Zürich, Switzerland. Annual meeting, on the Bürgenstock, near Lucerne, May 22 and 23, 1948.

PRELIMINARY PROGRAM

Thirtieth Annual Meeting of the American Radium Society

THE Thirtieth Annual Meeting of the American Radium Society will be held at the Stevens Hotel, Chicago, Illinois, on Sunday, Monday and Tuesday, June 20, 21 and 22, 1948. A very interesting program has been arranged with a number of foreign guests participating. Attention is called to the seven Refresher Courses which will be given by the foreign guests. Nonmembers may attend if there is room. Admission to these Refresher Courses will be by ticket and it is suggested that those interested should make application at once by writing to the President-Elect and Chairman of the Program Committee, Dr. Maurice Lenz, 840 Park Ave., New York 21, N. Y. Hotel reservations should also be made as soon as possible.

The scientific program has been arranged as follows:

Sunday, June 20, 1948

8:00 A.M.-12:00 M.: Refresher Courses

Experimental Comparison of Gamma and Roentgen Rays in Serial Biopsies. Constance Wood.

Intra-oral Cancer. Elis Berven.

Cancer of Pharynx and Larynx. François Baclesse.

Cancer of Uterus. Juliette Baud.

Cancer of Penis. Sir Stanford Cade and B. W. Windeyer.

Monday, June 21, 1948

8:00-9:00 A.M. Refresher Course

Carcinoma of Antrum. Sir Stanford Cade and B. W. Windeyer.

9:00-9:20 A.M. Presidential Address

9:20-9:30 A.M. Statistics. Eleanor J. MacDonald.

9:30 A.M.-12:30 P.M. Panel Discussion: End-Results of Treatment of Cancer of the Tongue.

Moderator: Douglas Quick.

Discussants: Juliette Baud, Elis Berven, Sir

Stanford Cade, Hayes Martin, Gordon E. Richards, B. W. Windeyer, Constance Wood.

1:30-2:00 P.M. Executive Session

2:00-4:00 P.M. Panel Discussion: Should Radiotherapy Be Separated from Roentgen Diagnosis?

Moderator: Aubrey O. Hampton.

Discussants: Elis Berven, Ross Golden, B. R. Kirklin, Robert R. Newell, B. W. Windeyer, Fred J. Hodges.

4:30 P.M. Janeway Lecture

The Achievement of Radium in the Fight against Cancer. Sir Stanford Cade.

7:00 P.M. Annual Banquet

Address: Fifty Years of Radium. Edith H. Quimby.

Tuesday, June 22, 1948

8:30-9:30 A.M. Refresher Course. Dr. Robert McWhirter.

9:30 A.M.-12:30 P.M. Panel Discussion: Treatment and Results in Cancer of the Breast.

Moderator: Maurice Lenz.

Discussants: François Baclesse, Elis Berven, Sir Stanford Cade, Cushman D. Haagen-sen, Robert McWhirter, Grantley W. Taylor, B. W. Windeyer.

1:30-2:00 P.M. Executive Session

2:00-4:00 P.M.

Roentgen Therapy of Advanced Cancer of the Cervix. François Baclesse.

Contact Roentgen Therapy of Cancer of the Rectum. Paul Lamarque.

Treatment of Metastatic Cancer of the Breast. J. R. Freid, H. Goldberg and A. Herrman.

Cancer of the Ear. C. L. Martin and J. A. Martin.

Radium Therapy of Advanced Salivary Gland Tumors of the Palate. Max Cutler.

Radium Therapy of Bartholin Gland Cancer. H. H. Bowing, R. E. Fricke and T. J. Kennedy.

DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., B.S., M.A., 103 Rutledge Ave.
Charleston, S. C.

RETROGRADE PYELOGRAPHY WITH THE USE OF THE FILMING ROENTGENOSCOPE*

By MAJOR ABRAHAM J. SCHECHTER, *and* CAPTAIN BERNARD D. PINCK

MEDICAL CORPS, ARMY OF THE UNITED STATES

ALTHOUGH retrograde pyelography has been developed into one of the more precise diagnostic procedures, certain deficiencies are known to exist. The customary method is essentially a blind procedure, engendering many errors in procuring completely diagnostic portrayal of the urinary tract.

The ideal film visualizes the entire tract with just the proper amount of radiopaque contrast material, without distortion, and with positioning best calculated to demonstrate the site and nature of the pathological alteration.

By the accepted standard technique, it is too often possible for even the experienced roentgenologist to produce an unsatisfactory or falsely reassuring pyelogram. The amount of dye introduced by gravity or injection may easily be inadequate or cause overfilling since reliance is placed on the doctor's judgment and experience, and on the sensations of a narcotized patient. It is not an uncommon experience to discover the need for supplementary views after the usual pyelogram has been made, necessitating change in position of the patient or table tilting. The degree of obliquity used is a matter of chance, table tilting is limited by the design of the urological table, and each failure, determined only after each film has been studied, demands repetition. In some instances, therefore, pyelography becomes a painstaking, tedious, time and film consuming procedure, intolerable to the patient.

Many have recognized the advantages of pyelographic performance under direct observation, in much the same manner that barium studies of the gastrointestinal tract are carried out under direct roentgenoscopic vision, with roentgenographic representation of only the critical diagnostic features. One could then use varying amounts of contrast medium, varying the position of the patient exactly as would best reveal the lesion that is being sought, and focussing directly over an area that seemed to merit special attention. The necessity for repetition would be reduced, and a speedier completion of the study with corresponding decrease in patient discomfort could be expected. There would be greater certainty in cystoscopic manipulation of ureteral calculi.

All this alone could be accomplished on most roentgenoscopic tables, but the value would not be nearly as great unless it were possible immediately to make films that are equal in quality to those usually obtained.

The apparatus available to us in a former German Naval Hospital has the necessary versatility for the purpose in mind. It is a 500 ma. rotating anode machine having a spot film device that includes a Potter-Bucky diaphragm. A variety of cassette carriers are available. The operator can make two exposures on a 30 by 24 cm. film to show almost an entire urinary tract, or he can make four exposures on a 40 by 15 cm. film to show only a renal pelvis and its calices. Other available sizes for single ex-

* From the 121st General Hospital, United States Army.

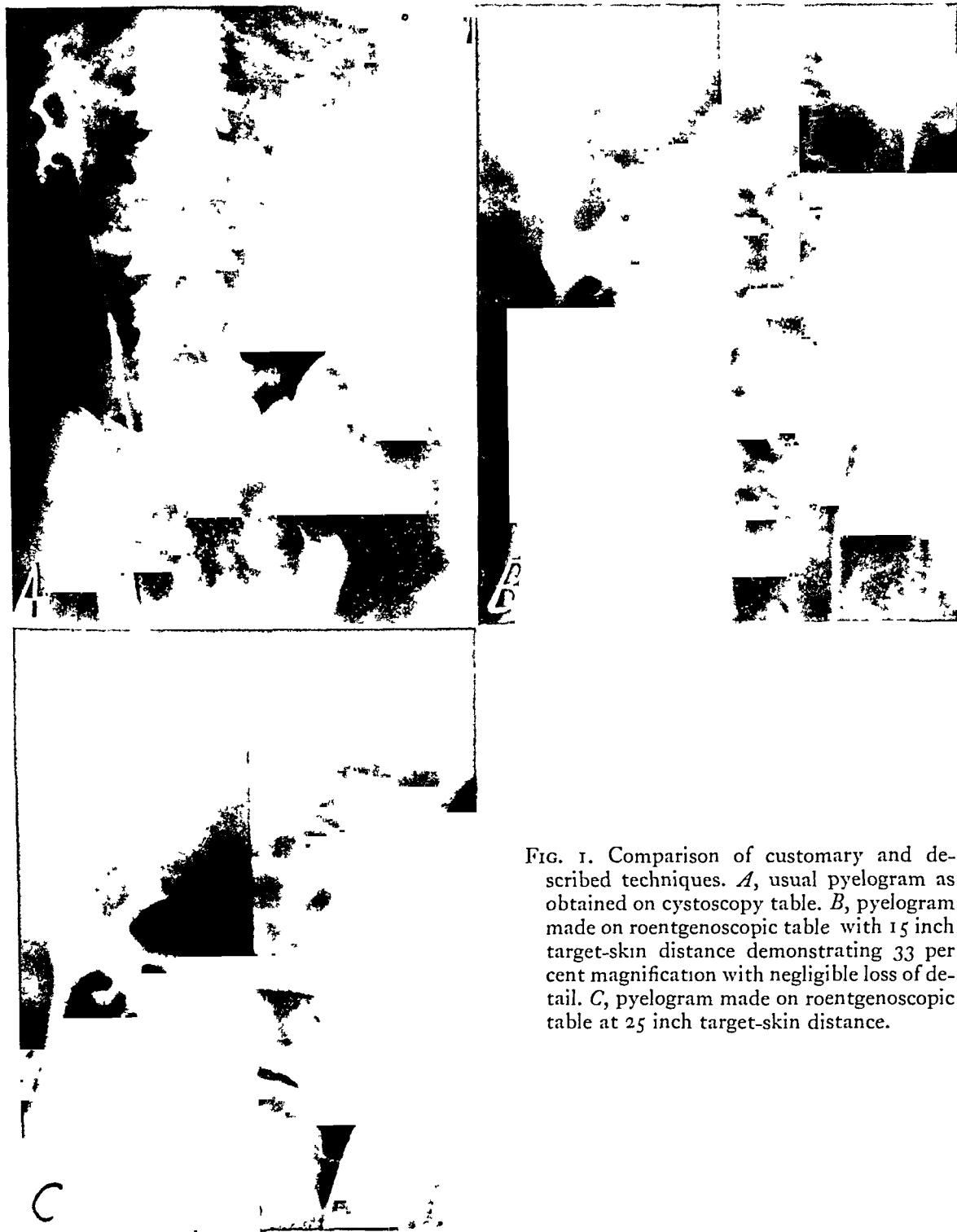


FIG. 1. Comparison of customary and described techniques. *A*, usual pyelogram as obtained on cystoscopy table. *B*, pyelogram made on roentgenoscopic table with 15 inch target-skin distance demonstrating 33 per cent magnification with negligible loss of detail. *C*, pyelogram made on roentgenoscopic table at 25 inch target-skin distance.

posures are 13 by 18 cm., and 18 by 24 cm.

Roentgenoscopy is done at 75 kv. (peak), 4 ma., at a target-skin distance of 15 inches. A handswitch permits immediate change to roentgenographic factors when

exposures are to be made. For average patients, 200 ma., 0.5 second, at 72 kv. (peak), has been found satisfactory, using Eastman blue brand or film of similar speed, and parspeed screens. The patient is

exposed to no more roentgen radiation than is usual for a carefully done gastrointestinal examination. Due to the shortened target-film distance, the structures under examination are magnified about 33 per cent, but loss of sharpness of outline is slight. At times the magnification has even seemed helpful. No special advantage was demonstrated when the target-patient distance

to most competently appraise the method in question and was modified by the apparatus and physical setup available.

Cystoscopy is performed in the usual manner and after ureteral catheters have been introduced into both renal pelves, the patient is transferred to the roentgenoscopy room. Initially for comparative consideration pyelograms were made in the custo-

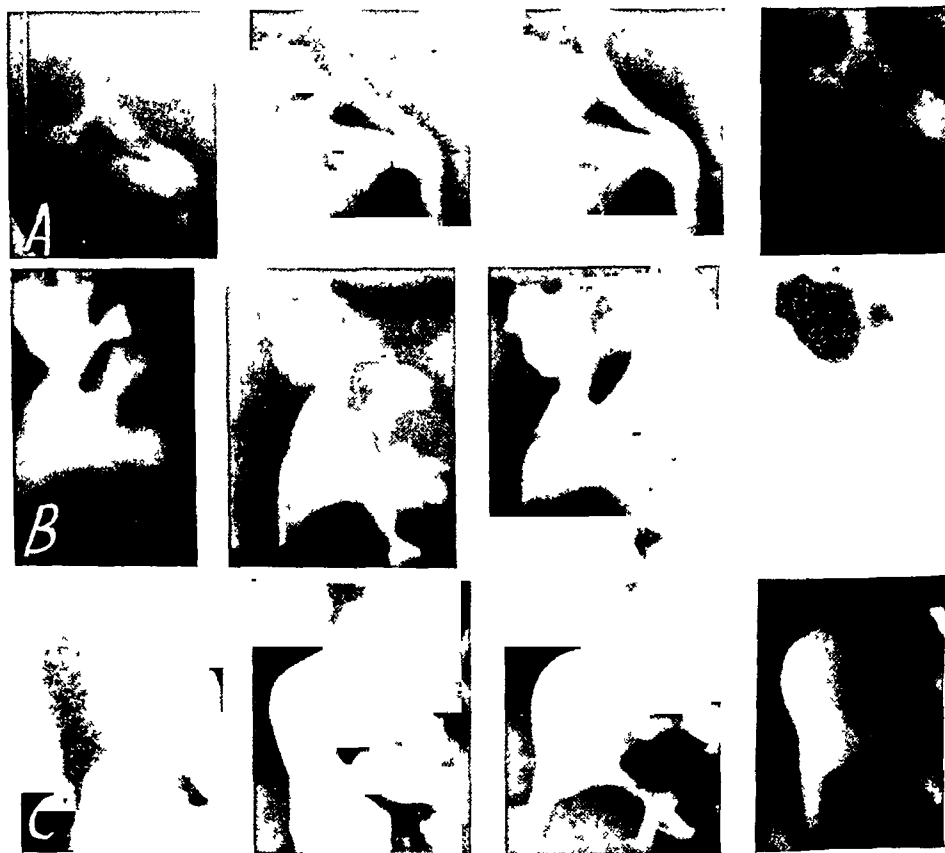


FIG. 2. Spot film studies of pelvis and calices, in series, on 15 by 40 cm. film.
A, Case I; B, Case II; C, Case III.

was increased another $10\frac{1}{2}$ inches by means of a plywood table placed on the roentgenographic table. The diminution in illumination of the roentgenoscopic screen under these conditions was a distinct disadvantage, even though magnification was reduced, and the interposed table was therefore abandoned. The technical procedure employed in the present study was evolved

in a preliminary fashion prior to roentgenoscopic observation. This preliminary step is now omitted.

Under construction at the present time are adjustable leg supports which can be appended to the roentgenoscopic table, thereby permitting cystoscopy on the same apparatus and eliminating the necessity for patient transfer.

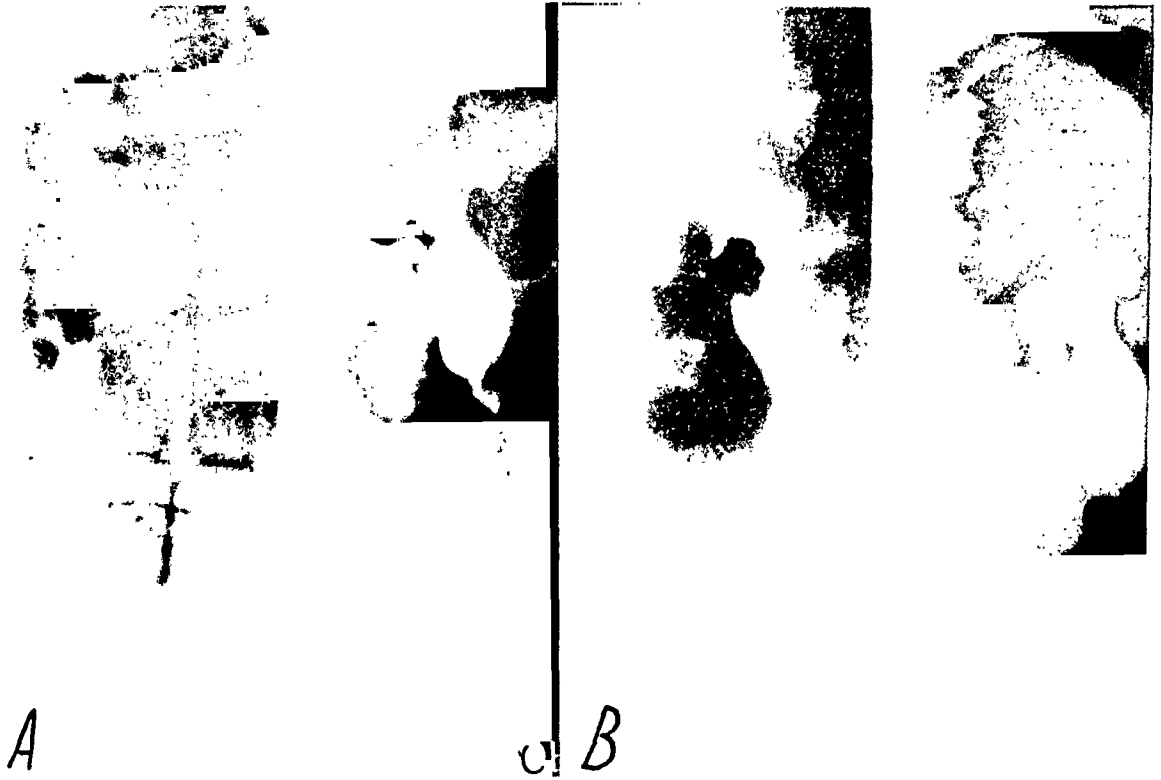


FIG. 3, *A* and *B*. Hydronephrosis secondary to obstruction at ureteropelvic junction, demonstrated roentgenoscopically and spot filmed in selected positions.



FIG. 4. Characteristic pyelogram by described method with two exposures on 30 by 24 cm. film.

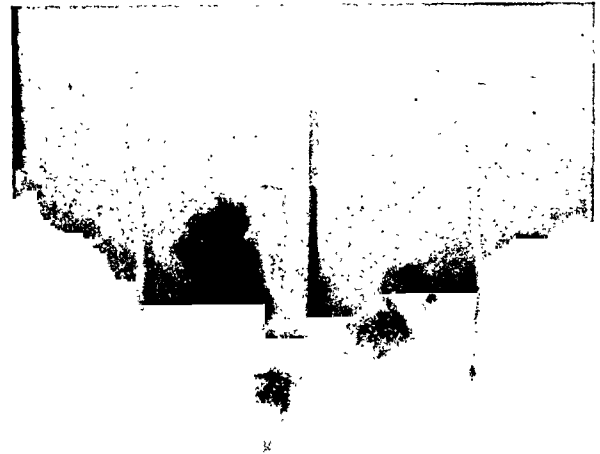


FIG. 5. Demonstration of ureteral store by new technique indicating advantage of magnification.

At the outset 20 per cent skiodan was employed as the desirable radiopaque substance. The dye at this concentration, while satisfactory for the usual pyelogram, was found to be an inadequate medium for roentgenoscopic study, providing only a pale shadow and a dull, inaccurate pyelogram. Excellent results were achieved, however, when a 40 per cent solution was used permitting accurate, detailed scrutiny as the dye is slowly injected up the urinary tract. Irritating or toxic effects of a 40 per cent solution of skiodan have not been encountered.

Illustrative examples of the method are shown in Figures 1, 2, 3, 4 and 5.

SUMMARY

To overcome recognized inadequacies in the usual procedure of retrograde pyelography, a method is described in which the filming roentgenoscope is used. Filling the pelvis and calices under direct observation makes it possible to vary the quantity of contrast medium and alter the position of patient and table to best demonstrate a pathological lesion. Spot filming with the apparatus described produces roentgenograms of high diagnostic quality. The method is useful in the manipulation of ureteral calculi.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

NECK AND CHEST

JENSEN, CLYDE R. Nonsuppurative poststreptococcal (rheumatic) pneumonitis. *Arch. Int. Med.*, March, 1946, 77, 237-253.

A case of rheumatic fever is presented in which death, due primarily to the pulmonary lesions of this disease, occurred thirty days after the onset of acute pharyngitis and fifteen days after the onset of rheumatic pain.

At autopsy each pleural cavity was free of adhesions and contained only a small amount of thin fluid. Large bronchi contained much moderately thick dark red fluid, their mucosa was dark gray-red. The main divisions of the pulmonary artery were free of clots. Peribronchial lymph nodes were large, soft and gray-black. The lung parenchyma varied from red to dark plum-purple, and was only slightly crepitant. The darker purple regions were not clearly demonstrated and were irregularly distributed and such regions particularly were rather solid, but not hard, more resilient than friable.

On microscopic examination few alveoli contained air. Many of them were filled with homogeneous material characteristic of edema fluid, and most of them contained cells also. Many of the cells were large mononuclear cells of phagocytic type, some containing a few fine spots of brown pigment, but so-called heart failure cells, heavily laden with brown pigment were sparse. Although rarely a giant cell with hyperchromatic and irregular nucleus was encountered, nothing resembling a true Aschoff nodule was found. No organisms were identified with the MacCallum-Goodpasture stain.—*James J. McCort.*

ZEMAN, FREDERIC D., and WALLACH, KAUFMAN. Pneumonia in the aged. *Arch. Int. Med.*, June, 1946, 77, 678-699.

In an effort to clarify some of the problems presented by pneumonia in old persons, the authors have studied 166 consecutive cases of pneumonia occurring in patients over sixty years of age from the wards of the Mount Sinai

Hospital and the Home for Aged and Infirm Hebrews, covering the period of five and one-half years between January 1, 1940, and June 30, 1945. In 143 of these, or 86 per cent, the clinical diagnosis of pneumonia was confirmed by roentgenologic examination, fluoroscopy or necropsy. One hundred and forty patients received sulfonamide drugs, 9 received penicillin and 2 were treated with both drugs.

There were 99 men with a mortality of 23 per cent and 67 women with a rate of 15 per cent. The greater number of cases occurred in persons aged sixty to seventy-five years. There is no correlation between age and mortality. Included in the series are 65 cases due to various types of pneumococci of which 8 terminated fatally, or 12 per cent. Penicillin was used successfully in 11 cases, including an empyema due to Type III pneumococci in a man aged eighty-four years and a meningitis due to Type II pneumococci in a man aged seventy-four years.—*James J. McCort.*

WALDENSTRÖM, JAN. Relapsing, diffuse, pulmonary bleedings or hemosiderosis pulmonum—a new clinical diagnosis. *Acta radiol.*, 1944, 25, 149-162.

Two cases with the typical picture of hemosiderosis pulmonum are described. The differential diagnosis of the roentgen picture of the lungs is not easy as there may be many causes of widespread infiltration in the lung fields.

1. Lymphogranuloma benignum.
2. Miliary tuberculosis.
3. Morbus Beanier-Boeck-Schaumann.
4. Pulmonary congestion due to heart disease.
5. Metastatic malignancy.
6. Pneumoconiosis.
7. Actinomycosis.
8. Blastomycosis.
9. Periarteritis nodosa.
10. Some types of xanthomatosis.
11. Miliary amyloidosis.
12. Purpura with intrapulmonary bleedings.—*Mary Frances Vastine.*

THOMPSON, L. E., and GERSTL, B. Thromboangitis of pulmonary vessels associated with aneurysm of pulmonary artery. *Arch. Int. Med.*, June, 1946, 77, 614-622.

This paper reports a case in which an aneurysm of the right pulmonary artery of more than 10 cm. in diameter developed within a period of three months and was associated with thromboangiitis of both pulmonary arteries and veins.

The patient died and at autopsy it was found that the middle lobe of the right lung was displaced by a globe-like structure with a firm capsule of grayish dark purple color. It had dislocated the lower lobe posteriorly and laterally. On removal and incision the lesion measured 12 cm. in diameter and was largely occluded by a laminated clot of blood. Only a small tangential segment of the upper anterior lobe contained fluid blood. The part of the capsule adjacent to the hilum differed from the peripheral parts in its yellowish white color and in its firm structure. The compressed and atelectatic parenchyma of the middle lobe was found at the upper circumference of the lesion. Two large vessels were located medially from its upper pole. The one situated cranially was rather thin walled and measured 3 cm. in diameter. A bronchial lumen was noted at the upper circumference of this vessel. A second vessel was located between the large one just described and the wall of the globe shaped aneurysm.

Microscopically the wall of the aneurysm was composed of bundles of fibrous connective tissue that were usually densely arranged. At some points, however, the connective tissue fibers were spread apart by monocytes, many of which showed a foamy cytoplasm. A few smooth parallel muscle films could be identified close to the hilum, while fragments of wavy elastic fibers were seen in sections of peripheral segments of the wall of the aneurysm.—James F. McCort.

WEENS, H. STEPHEN, and HEYMAN, ALBERT. Cardiac enlargement in fever therapy induced by intravenous injection of typhoid vaccine. *Arch. Int. Med.*, March, 1946, 77, 307-316.

In treating patients with neurosyphilis with fever induced by the intravenous administration of typhoid vaccine, the authors have noted in roentgenographic examination that cardiac

enlargement occurred in a significant number of cases.

Teleroentgenograms of the heart were taken on 15 patients preceding fever, following each paroxysm and several weeks after the completion of therapy. In a second group of 24 patients, teleroentgenograms were made before fever therapy and several months after its completion. In every repeat examination a special effort was made to obtain roentgenograms with the diaphragm in a position comparable to that of the original film; when this was not possible, the patients were excluded from the study.

The size of the heart was determined in each roentgenogram by measuring the transverse diameter, since this seemed to be the simplest and most accurate method of obtaining comparable values. It is stated that in normal patients the amplitude of the right border of the heart varies from 2 to 3 mm. and that of the left border from 3 to 5 mm. Changes in the transverse diameter less than 8 mm., therefore, were not considered significant in this study.

Enlargement of the heart has been noted by roentgenographic examination to occur during fever therapy in 8 of 15 patients with neurosyphilis.

Roentgenograms of the heart were obtained on 24 additional patients who had undergone fever therapy during the preceding twelve months. In 4 of these patients, cardiac enlargement was present for as long as six months following hyperpyrexia.—James F. McCort.

VESELL, HARRY, and KROSS, ISIDOR. Patent ductus arteriosus with subacute bacterial endarteritis. *Arch. Int. Med.*, June, 1946, 77, 659-677.

Since it has been demonstrated that ligation or excision of the ductus can terminate the superimposed bacterial endarteritis, the authors feel that all patients in whom the diagnosis is definitely established should be operated on promptly with two exceptions. These exceptions are, first, patients with important associated congenital cardiac anomalies for which the ductal shunt is a vital compensatory mechanism and, second, patients with evidence of extension of bacterial vegetations beyond the ductus and pulmonary artery, particularly those with involvement of the left side of the heart.

Many observations contribute to the diag-

nosis of patent ductus arteriosus and subacute bacterial endarteritis. The usual history is that the patient was not a "blue baby." The presence of a cardiac murmur from infancy was almost always known. Cyanosis did not occur except with pulmonary or cardiac complications. The most helpful diagnostic sign was the characteristic "train in a tunnel" machinery murmur.

The authors report a case where an initial trial with penicillin therapy was not completely successful and final care was uncertain. In this case the patient was then treated with penicillin and surgical measures with recovery.—*James J. McCort.*

ABDOMEN

CHEVALLIER, PAUL, and MOUTIER, FRANÇOIS.
Oedèmes angio-neurotiques de l'estomac.
(Angioneurotic edema of the stomach.)
Presse méd., Dec. 25, 1946, 54, 860-861.

Gastrosopies performed in various diseases show that the stomach is quite often the site of edema. This edema, generalized or localized (lesser curvature, angulus, antrum), is a frequent component of various types of gastritis. When it is localized, the roentgenological picture, portraying filling defects and rigidity of either curvature or of the entire antrum, is quite suggestive of malignancy. The authors have followed several such cases by repeated gastrosopies and have seen edematous areas shrink to normal.

The main object of the paper is to present cases of angioneurotic edema of the stomach. This edema was found to be only one of the allergic phenomena present in these patients and in each instance the offending allergin was traced to some food. All of the patients had gastrointestinal complaints and, on gastrosopy, showed either generalized or localized edema. In one instance there was a single wheal the size of a walnut. In each case, following withdrawal of the offending food, examination showed disappearance of the lesion. This study demonstrates that edema of the stomach may appear after the ingestion of an allergin and can produce roentgenological findings of various types, including localized filling defects and rigidity of the antrum. If the radiologist is not aware of the existence of allergic manifestations these findings may be very misleading.—*Gilbert H. Fletcher.*

WALTERS, WALTMAN. Diverticula of the stomach. *J.A.M.A.*, July 20, 1946, 131, 954-956.

The incidence of diverticula of the stomach is low. Rivers, Stevens and Kirklin reported that 4 gastric diverticula were found in 3,662 necropsies done routinely and that 10 gastric diverticula were removed in 11,234 exploratory operations on the stomach at the Mayo Clinic. Diverticula of the stomach have been classified as (1) true (congenital) diverticula, in which all layers of the stomach are intact and the diverticula are caused by malformations or arrested development during the fetal period, and (2) false (acquired) diverticula. The author reports 5 cases in which the diverticula were for the most part the congenital type.

All 5 patients had definite symptoms of epigastric fullness and dyspepsia. Associated with the feeling of fullness was a sense of discomfort. In several there was periodic, burning or gnawing pain. In all of Walters' cases roentgenologic examination of the stomach revealed a classic diverticulum and gastroscopic examination was made in only 1 case. Excision of the diverticulum was followed by relief of symptoms.

Retention of food in the diverticulum undoubtedly produces gastrospasm; this, plus the diverticular gastritis, accounts for the pain.—*Samuel G. Henderson.*

WEBER, HARRY M. Roentgenologic contribution to the diagnosis of functional intestinal disorders. *J.A.M.A.*, May 17, 1947, 134, 226-229.

There are three fundamental kinds of intestinal activity: secretion, absorption and motility. Intestinal function is the sum of these activities. In health they cooperate in a literal sense to effect what is called a "normal" or "healthy" intestinal function. In disease any maladjustment of or interference with one of the basic activities is associated with or may actually cause observable change in the performance of the other two. Roentgenologic studies on the physiology of the intestine are usually concerned with the phenomena of its movements. Since the basic intestinal activities are interrelated so intimately, deductions about the secretory and absorptive activities may often be made from observations on intestinal motility.

Intestinal Dysfunction Associated with Disease in the Intestine Itself. Pathological struc-

tural alteration in the intestine that has reached macroscopic proportions can be expected to produce functional change of some degree. Such structural change may be the result of a neoplastic or inflammatory process or of congenital or acquired anomalies of intestinal structure which become pathogenic only under certain circumstances, such as diverticula, anomalies of size, fixation and position and other structural intestinal defects. The most important contribution roentgenologic diagnostic maneuvers make to the diagnosis of functional intestinal disorders is the efficient role which they play in the exclusion of organic intestinal disease as the cause of a given set of clinical manifestations of functional intestinal derangement. Advances in roentgenologic diagnosis in general, and in the field of gastroenterology in particular, have been closely linked with the development and definition of morphologic syndromes on which a pathologico-anatomic diagnosis can be constructed. Today such roentgenologically observable changes in the intestinal tract as local or general hypermotility, hypomotility, hypertonus, hypotonus, spastic phenomena and changes in the secretory and absorptive activities that can be exhibited with the use of roentgen rays are made use of chiefly to stimulate an intensified search for a cause. This cause is presumed to be organic, that is, structural, until proved otherwise. There are few, if any, roentgenologic syndromes of organic gastrointestinal disease in which the accompanying functional alterations have the necessary quality of definitiveness.

Intestinal Dysfunction Associated with Extra-intestinal Disease or Dysfunction. Disturbance in the physiological activities of the intestine, sometimes of considerable magnitude, is also observed to exist in association with organic change in or functional derangement of adjacent or neighboring extraintestinal but intra-abdominal viscera. The manner in which the intestinal disturbance is brought about—its mechanism—may be obvious in most instances but in others it is understood poorly or not at all. The same may be said of intestinal dysfunction resulting from, or seen in association with organic and functional alteration in the central nervous system and in diseases that are more or less systemic in their effects and manifestations like the chronic infectious diseases, nutritional deficiencies, endocrinologic and metabolic disorders, ocular and labyrinthine diseases and addictions to drugs. The author designates

all these varieties of intestinal dysfunction fundamentally neurogenic in origin, for in one way or another, the intestinal disturbances may be considered as resulting from imbalance of the autonomic innervation of the intestine or from a functional or organic disturbance in its intrinsic innervation. Roentgenologically demonstrable functional changes that are in any way characteristic are observed in one category only, that of the nutritional deficiencies, in which is included the poorly defined but similar syndrome developed as a result of digestive secretory deficiency.

Intestinal Dysfunction without Demonstrable Cause or Association. Intestinal dysfunction without demonstrable anatomic or physiologic cause may be said to occur in the large intestine, in the small intestine, in restricted parts of either or in both divisions at the same time. One clinical type is recognized in which the symptoms and signs indicate that the intestinal motility is chiefly disturbed; in another type, symptoms of secretory dysfunction predominate; in a third type, evidence of disturbance of both functions is observed. Simple constipation and so-called functional diarrhea are either included in one of these types or are treated as separate functional entities. The manner in which the functional derangement is produced is unknown, but the underlying factor is presumed to be a subtle psychogenic or emotional disturbance related to the intestine through the medium of the autonomic nervous control of the several intestinal activities. It is often necessary to induce rather drastic changes in what is called the "normal" physiologic condition of the intestine preliminary to the roentgenologic examination; some of these changes are not easily distinguished from pre-existing physiologic abnormalities. The rigorous purgation necessary to prepare the colon for examination with the opaque enema, the prolonged fasts preliminary to examinations of the stomach and small intestine and the administration of antispasmodic drugs must receive their share of attention when the diagnosis of a functional intestinal disorder is being considered. Fear, apprehension, modesty, impatience and many other adverse psychologic reactions immediately connected with the conditions of the investigation, may be the cause of minor, but also of major deviations from the somewhat arbitrary standards of normal intestinal activity. The opaque enema is an unnatural, unphysiologic and to most patients an abhorrent

procedure. The evidence of abnormal physiologic change brought to light with its use is highly unreliable. The opaque meal may be unpalatable or nauseating to the patient, a circumstance which may alter the motility of the small intestine. Medication that the patient has been receiving must be given consideration as to whether it has affected the intestine primarily or not. Another source of confusion in the roentgenologic diagnosis of primary functional intestinal disorders is related to diagnostic nomenclature. One rarely finds convincing roentgenologic evidence of intestinal irritability or of hypersecretion of mucus in patients whose clinical symptoms warrant, in the opinions of gastroenterologists, such diagnosis as "irritable colon," "spastic colon", "unstable colon" and the current equivalent of the term "mucous colitis."

In conclusion, the author again voices his conviction that the greatest contribution which the roentgenologic examination of the intestine makes is the facility and accuracy with which it can be made to exclude organic intestinal disease as the cause of the clinical manifestations of dysfunction.—*Samuel G. Henderson.*

EHRlich, J. C., and HUNTER, O. B. Tumors of the gastrointestinal tract. *Surg., Gynec. & Obst.*, July, 1947, 85, 98-106.

A general survey of the tumors arising in the gastrointestinal tracts of members of the armed forces between eighteen and thirty-eight years of age has been made. The most salient features brought out are these:

1. Carcinoma of the large intestine and rectum constituted over three-fourths of all the carcinomas of the gastrointestinal tract.
2. Carcinomas were most frequent in the older age group, but mortality was relatively higher in the younger age group.
3. Polypoid lesions of the intestinal tract were observed most commonly in the rectum. No recurrences resulted after local excision.
4. Carcinoids occurred most frequently in the appendix, but those in the rectum were commonly confused with carcinomas.
5. The most frequent tumor of the lymphoma group was the benign lymphoid polyp. These tumors were commonly found in the rectum, and local excision was followed by no subsequent evidences of recurrence

or transformation into the malignant types.

Among the less common tumors in this survey there were 7 malignant melanomas, 6 of them metastatic in origin; only 1 was believed to have arisen in the ileum. Four neurofibromas were located in the appendix and were discovered at operation for what appeared clinically to be acute appendicitis. One ganglioneuroma of the cecum occurred; it measured 6 cm. in diameter. In the 1 instance of hemangioma recorded, the lesions were multiple and were located in the ileum. One unusual gastric tumor was a hemangiopericytoma; others were hamartoma of the stomach and undifferentiated sarcoma of the jejunum. Lipoma, myxoma, lymphangioma, teratoid and other tumors, sometimes reported to occur in the gastrointestinal tract, were not observed in this series.

There were 8 cysts of the gastrointestinal tract, 4 related to the esophagus and 4 to the small intestine. Three of those in the esophagus were lined by respiratory epithelium and 1 by epidermis. Of the 4 in the small intestine, 1 was a parasitic cyst due to ankylostomiasis; the other 3 were enteric cysts, lined by columnar epithelium. One mucocele was seen in the rectum; it was associated with a polyp. Of interest, too, was a case of pneumatosis cystoides intestinalis for which a segment of ileum was resected. The patient was subsequently found to have a duodenal ulcer from which gas escaped into the tissues. Three cases of endometriosis were reviewed; 2 of the lesions were in the appendix and the other in the ileum.—*Mary Frances Vastine.*

POTTS, WILLIS J. Congenital atresia of intestine and colon. *Surg., Gynec. & Obst.*, July, 1947, 85, 14-19.

The prognosis is good for a full term infant who is normal except for atresia of the bowel and who is operated upon on the third or fourth day of life. During the past six months, 5 patients with congenital atresia of the bowel have come under the author's care.

Diagnosis. Vomiting is the outstanding symptom. It begins the first or second day after birth and is persistent. The majority of atresias are below the ampulla of Vater and the vomitus contains bile.

Distention varies with the level of the obstruction.

Roentgen examination is of great help in

establishing the diagnosis. The roentgenogram should be made with the infant in the upright rather than the supine position. If obstruction is present, widely distended loops of bowel showing fluid levels will be seen. Furthermore the roentgenogram will indicate whether the obstruction is high or low. Positive differentiation of duodenal, ileal, or colonic obstruction is impossible because of the enormous dilatations seen and because these loops crowd one another into abnormal positions. The administration of barium to these babies is condemned. Its use is unnecessary to make a diagnosis of obstruction, it clogs the intestine and, if aspirated, tends to produce pneumonia.—*Mary Frances Vastine.*

VYNALEK, WILLIAM J., SAYLOR, LESLIE L., and SCHREK, ROBERT. Carcinoma of the colon. *Surg., Gynec. & Obst.*, April, 1947, 84, 669-677.

This paper represents a study of all the patients with carcinoma of the colon, not including the rectum and rectosigmoid, admitted to the Veterans Administration Hospital, Hines, Illinois, from 1931 to 1945 inclusive.

Symptoms. Abdominal distress—usually most marked in the region involved. However, obstruction of the left colon may cause most distress in the dilated right bowel.

Change in bowel habits is an important and frequent symptom elicited only by a carefully taken history.

Mass in the abdomen was mentioned by the patient himself in 25 per cent of the cases with involvement of the cecum or ascending colon, by 6 per cent of the sigmoid group and rarely by others.

Weight loss is often an early sign and was present in practically all these cases.

Blood in the stools was mentioned in the histories of 33 per cent of the patients with lesion in the left half of the bowel and by 8 per cent of those with right colon involvement.

Anemia was uncommon in this series. Indigestion, weakness, nausea, vomiting, anorexia and fever were frequently mentioned.

Findings. A palpable mass was noted in 81 of the 102 cecal cases, 14 of the 53 ascending colons, 20 of the 27 hepatic flexures, 26 of the 55 transverse colons, 11 of the 27 splenic flexures, 22 of the 49 descending colons, 87 of the 173 sigmoids, averaging 69 per cent.

Tenderness at the site of involvement was a frequent finding.

Occult blood was usually positive.

Barium enema roentgen studies practically always revealed a suspicious defect. The segment where pathology was most often overlooked was the sigmoid in which roentgen studies missed the lesion in 9 per cent of the cases.

Pathology. Adenocarcinoma of a colloid modification was the usual finding. In lesions thought by the operator to be nonresectable, a large firm mesenteric gland was frequently taken for biopsy and the pathologist's report was usually negative for carcinoma. This implies that neither surgeon nor pathologist is able to diagnose cancer of the lymph nodes grossly or to differentiate it from inflammation.

Multiple polyposis was noted in 11 (2.2 per cent) of the 486 patients in this study.

In 3 instances multiple cancers of the large bowel were found.

Irradiation. Irradiation was used frequently as a "palliative" measure in the earlier years with no outstanding improvements. Doses of a total of 100 to 6,000 roentgens are reported but deep therapy is no longer considered of much value for lesions above the rectosigmoid. *It was felt that roentgen therapy following drainage of abscesses definitely shortened the period of waiting preparatory to radical surgery.*—*Mary Frances Vastine.*

COLCOCK, BENTLEY P. Prognosis in carcinoma of the colon and rectum. *Surg., Gynec. & Obst.*, July, 1947, 85, 8-13.

The case histories of 81 patients who had resection for carcinoma of the colon 10 or more years ago have been reviewed. Of the patients with favorable lesions (that is, those in whom the adjacent lymph nodes were not involved and in whom there was no local invasion of the surrounding tissues), 64.3 per cent survived five years without recurrence and 57.1 per cent are living and well without recurrence ten or more years following resection of their malignant tumor.

Of the patients with unfavorable lesions (that is, those in whom the lymph nodes showed evidence of metastases or there was invasion of the surrounding structures by the tumor), 15 per cent were living and well five years after operation. Eleven per cent are living and well ten or more years following resection.

The histories of 146 patients who had had a radical resection for carcinoma of the rectum

or rectosigmoid ten or more years ago were also reviewed. In the favorable group, 60 per cent were found to be well without recurrence at the end of five years; at the end of ten years this figure had dropped to 51.6 per cent.

In the less favorable group, 30.2 per cent survived five years without a recurrence. Only 23.2 per cent are living and well ten or more years following their operation.

Of the patients who died from malignant disease between the fifth and tenth postoperative years, the majority died between 5.5 and 6.5 years following operation. All of these patients gradually failed and died with the signs and symptoms of carcinomatosis of the abdominal cavity.

Conclusions. These figures suggest that in a patient with carcinoma of the rectum in whom the mesenteric lymph nodes of the resected specimens show no evidence of carcinoma, the prognosis is approximately twice as favorable as it is for a patient in whom the lymph nodes are positive. The unfavorable significance of positive lymph nodes in carcinoma of the colon appears even greater.

The figures also suggest that, although some patients who are living five years after resection for carcinoma of the colon or rectum will ultimately die of their disease, more than 50 per cent of those who survive this operation and in whom the mesenteric lymph nodes are negative for carcinoma may expect a permanent "cure" of their malignant disease from a radical surgical resection.—*Mary Frances Vastine.*

GYNECOLOGY AND OBSTETRICS

THOMS, HERBERT. The role of nutrition in pelvic variation. *Am. J. Obst. & Gynec.*, July, 1947, 54, 62-73.

Roentgenography has revealed that the adult female pelvis is subject to considerable variation in its anteroposterior relationships. These variations have a definite clinical interest to the obstetrician for in instances they may have a pronounced effect upon the course of labor.

The so-called "normal" female pelvis of anatomical texts needs revision because the architecture usually described is that of the brachypelvic or oval type, which is present in about only one-third of adult women according to evidence presented here.

The pelvis of infancy and childhood in both sexes is essentially similar as far as anteropos-

terior relationships are concerned; until a time just preceding the puberal period they tend to grow symmetrically. At that time changes in anteroposterior and transverse relationships take place. These changes are apparently the result to two major influences: sex hormonal and nutritional. It would seem on first appraisal that such hormonal influence was the dominant factor because of the well known somatic and psychic phenomena associated with the puberal period. Nevertheless, wide variations in pelvic architecture are present in our adult population which are apparently unrelated to such phenomena.

Evidence is given to show that nutritional influences during the puberal period seem also to have a major role in these changes in anteroposterior and transverse pelvic relationships. This role seems to be associated closely with calcium and vitamin D requirements.

This evidence presented here emphasizes the need for further study of the nutritional requirements of the growing child, particularly during the puberal period.—*Mary Frances Vastine.*

CALMENSEN, MARVIN; DOCKERTY, MALCOLM B., and BIANCO, JOHN J. Certain pelvic tumors associated with ascites and hydrothorax. *Surg., Gynec. & Obst.*, Feb., 1947, 84, 181-191.

A definite clinical syndrome (Meigs' syndrome) consisting of ascites and hydrothorax associated with fibroma of the ovary has been recognized in recent years. Certain other benign pelvic tumors may now be identified as causing this syndrome, which is of considerable importance because it presents a clinical picture usually associated with inoperable malignancy and pleural metastasis. In the group of lesions under consideration almost magical relief is afforded by surgical extirpation of the tumor.

Conclusions. Nine cases of pelvic tumor associated with ascites and hydrothorax were found in the records of the Mayo Clinic. The 9 cases included 5 ovarian fibromas, 1 degenerating uterine fibromyoma, 1 fibromyoma of the uterus with pelvic inflammatory disease of the adnexa, 1 granuloma-cell tumor of the ovary, and 1 complex teratoma of the ovary. Pathologically, all the tumors were of the solid variety, and were large, averaging 16 cm. in diameter. Gross edema of the tumor was noted in each of

the specimens. Microscopically, intercellular edema was noted in each tumor. It would seem that this edema can be correlated with the clinical production of ascites in each case. A large solid tumor can readily produce partial venous obstruction, edema, and in turn ascites. Partial obstruction to the venous return also may result from twisting of a pedicle, inflammation, or adhesions. In 7 of the cases, hydrothorax was situated on the right side. It was bilateral in 1 case and had occurred on the left side in 1 case. On the basis of the evidence reviewed, it appears that the fluid in the thorax results from the passage of ascitic fluid through the diaphragmatic lymphatic vessels.—*Mary Frances Vastine.*

CROSSEN, ROBERT J. Advances in practical prevention of gynecologic cancer. *Am. J. Obst. & Gynec.*, Aug., 1947, 54, 179-187.

Cancer prevention involves the removal of chronic irritation, by conization for cervicitis and by vulvectomy for leucoplakic vulvitis, and the removal of involution ovaries and uterus under suitable circumstances.

Periodic examinations are necessary to discover chronic irritation before malignant development starts and to discover cancer in involuting ovaries or uterus or breasts while it is still in a curable stage. Yearly check-ups were formerly considered sufficient, but owing to the difficulties of detecting early ovarian cancer that interval is too long to guard the patient against advanced malignancy. That fact was learned by bitter experience by the author. A patient whose adnexal areas were apparently clear on examination, returned seven months later with an irremovable ovarian cancer. Careful check-ups at six month intervals for the two decades, aged forty to sixty years, constitute the minimum requirements for reasonable safety from incurable malignancy.

In addition to the usual deep pelvic palpation and the speculum examination and the check of the breasts for beginning infiltration, the check-up should include percussion of the flanks for possible ascitic fluid in the peritoneal cavity is often the first demonstrable sign of the chronic peritoneal irritation associated with ovarian carcinomatous infiltration.

Owing to the cancer-potential of the involuting ovaries and the "silent" advance to incurability of most ovarian cancers, it is advisable to remove the involuting ovaries whenever the

abdomen is opened in the climacteric age (forty-three years and later).

The cancer-potential of the involuting endometrium should be taken into consideration when handling non-malignant uterine conditions requiring serious treatment. For example, a myoma causing persistent serious symptoms in spite of palliative measures confronts us with the alternative of stopping the myoma activity by radium treatment (with curettage to exclude malignancy and conization (if cervicitis is present) or removing the growth by the major operation of hysterectomy.

This calls for a careful consideration of three factors, namely (a) the chance in that particular case of securing relief by the radiation program, (b) the future risk of malignant development in uterus or ovaries, and (c) the immediate risk of hysterectomy and double oophorectomy. It has been found that though the risk of future malignant development is cut to one-third by radium treatment, there still remains a malignancy risk of 0.89 per cent. The mortality risk of hysterectomy and double oophorectomy may be reckoned at 1 to 2 per cent, depending on the condition of the patient and the skill of the operator.

In general, for the good operative risk, the seriously troublesome myoma occurring in the age of involution is preferably handled by complete hysterectomy and double oophorectomy. On the other hand, for the seriously handicapped patient, the radium plan in a suitable case is a lifesaving measure, in that it stops the serious myoma activity without the great risk of a major operation.

Leukoplakic vulvitis eventuates in cancer in a considerable proportion of the cases. In Tausig's series of 155 vulvar cancers, nearly half were preceded by leukoplakic vulvitis. Hence, the importance of prompt vulvectomy for this condition, unless there is a good response to vitamin A therapy as suggested by Hymans and Bloom.

Delayed menopause indicates erratic endometrial and ovarian activity which increases the susceptibility to malignant development. It should be stopped by radium treatment, with associated curettage to exclude endometrial malignancy, conization if cervicitis is present, and accurate palpation of the ovarian areas under anesthesia, with recording of findings for future reference and comparison.—*Mary Frances Vastine.*

DEALVAREZ, RUSSELL R. The causes of death in cancer of the cervix uteri. *Am. J. Obst. & Gynec.*, July, 1947, 54, 91-96.

The causes of death in 55 patients dying with carcinoma of the cervix have been reviewed and analyzed.

1. Ureteral obstruction (40 per cent)
Pulmonary causes (31 per cent)
Gastrointestinal causes (13 per cent)
2. Nephrostomy, cutaneous ureterostomy, palliative colostomy, and shunting bowel anastomoses may not only lengthen life but may also be lifesaving measures. While nephrostomy and ureterostomy have not yet reached perfection, their continued and more frequent use may lead to improved technique.—*Mary Frances Vastine.*

CORSCADEN, JAMES A., and GUSBERG, S. B. The background of cancer of the corpus. *Am. J. Obst. & Gynec.*, March, 1947, 53, 419-427.

It would appear that an unmarried woman and if married, childless, who is overweight and in comfortable circumstances is a likely candidate for a cancer of the corpus uteri at some time in her life. If her menopause is characterized by excessive bleeding, the chances of her contracting carcinoma are still greater.

There are several fragments of evidence suggesting abnormal estrogenic stimulation as one of the growth-stimulating factors.

The evidence presented suggests that women destined to have carcinoma of the corpus are measurably different from other women.—*Mary Frances Vastine.*

GENITOURINARY SYSTEM

BACON, S. K. Large hydronephrosis of a true supernumerary kidney. *J. Urol.*, March, 1947, 57, 459-466.

Supernumerary kidney is the rarest congenital anomaly, only 43 cases having been reported in the literature. It must be distinguished from simple reduplication, a common finding. The anomaly occurs when duplicated or bifurcated excretory ducts extend cranially to enter two independent metanephrogenic masses.

Renal anomalies predispose to pathological lesions. Calculi and infections predominate. The author reports a case of true supernumerary kidney with hydronephrosis in a forty-seven

year old woman who complained of right lower quadrant pain of several years' duration. No palpable masses were noted on physical examination. The patient was operated upon for chronic appendicitis and a band of supposed adhesions was found, which the surgeon suggested might possibly be a right ureter. One month after operation the patient was referred to a urologist with the history that the right side of her abdomen had begun to enlarge one week after the previously described operation. Physical examination revealed a cystic mass occupying the entire right side of the abdomen and extending across the midline. At cystoscopy two normal ureteral meati were found, there being no evidence of urinary activity on the right. A catheter was introduced into the right ureter and appeared to enter a large cavity.

A plain film of the abdomen revealed a soft tissue mass on the right and this mass was found to cause displacement of a catheter in the right ureter to the midline. A bilateral pyelogram with 200 cc. of skiodan injected on the right revealed an enormous hydronephrosis with normal appearing kidney substance above the hydronephrotic sac.

At operation two separate kidneys were exposed on the right. The upper kidney was normal, the lower was the site of an enormous hydronephrosis. The diseased lower kidney was removed. There was some constriction of the ureter to the upper kidney causing a mild obstructive uropathy. This gradually improved following ureteral dilatation.—*Rolfe M. Harvey.*

CECIL, A. B. Adenoma of the kidney. *J. Urol.*, March, 1947, 57, 446-450.

Adenomas of the kidney of sufficient size to produce symptoms are rare, only 23 cases having been reported up to 1945. The tumors may occur at any age and may reach a large size. Two groups of these tumors occur: multiple small tumors which are fairly common and large single tumors, producing signs and symptoms, which are rare.

Adenomas may be further classified as papillary, showing cystic spaces into which papillae project; tubular, showing long canals lined by fat-free cells with large nuclei; and alveolar, which have polyhedral cells arranged in alveolar form.

The author reports a case of a fifty-nine year old man who complained of nasal and rectal

bleeding and an abdominal mass. Physical examination showed a mass the size of a fist in the left upper quadrant of the abdomen which moved with respiration. The mass was firm and slightly nodular. Intravenous pyelogram showed displacement of the left ureter toward the midline. A bilateral retrograde pyelogram showed displacement of the left ureter by a soft tissue mass which could be outlined below the lower pole of the left kidney. The mass was thought to be separate from the kidney and a preoperative diagnosis of retroperitoneal mass was made.

At operation the mass was found to arise in the left kidney. A histopathological diagnosis of adenoma of the kidney was made. The patient died six years later of portal cirrhosis.—*Rolfe M. Harvey.*

NOLLE, B. C., JR. Distant metastases of 58 renal neoplasms; a case report of secondary metastatic pulsations, from a renal tumor. *J. Urol.*, April, 1947, 57, 662-668.

Renal neoplasms often present no urological symptoms until the local growth is advanced and then frequently the only symptoms are those of distant metastases. The author analyzes a group of 58 cases of renal neoplasm beyond the first decade of life. Only 58 per cent of the complaints of this group were referable to the urinary tract. Of the complaints from the other 42 per cent constitutional symptoms of malignancy were present in 18 per cent, gastrointestinal complaints in 14 per cent, cardiorespiratory complaints in 5 per cent, central nervous system complaints in 4 per cent and skeletal complaints in 1 per cent. In 50 per cent of the entire group the classical triad of hematuria, pain, and swelling were absent. Fever was the only complaint in 3 cases.

Metastases to the chest occurred in 44.8 per cent, to the deep organs in 18.9 per cent and to the lymph nodes in 15.5 per cent. Only 1 case showed metastases to the opposite kidney.

The author reports a case of a fifty-two year old white male who developed rheumatoid pain in the left groin. This had been present for three months. Two weeks before admission he noticed a lump in the left shoulder area which grew rapidly. This mass was the size of a lemon and pulsated synchronously with the heart. A thrill and bruit were present. The same characteristics were present in a left inguinal mass. Roentgen examination disclosed complete de-

struction of the outer 6 cm. of the left clavicle and of the lateral border of the left ilium. The roentgen report suggested the possibility of metastatic renal hypernephroma.

A left pyelogram showed distortion of the left kidney pelvis and calices consistent with tumor. The final clinical impression was malignant hypernephroma of the left kidney, with multiple pulsating metastases to the left clavicle and ilium. The author reviews the literature on pulsating metastases from renal tumors.—*Rolfe M. Harvey.*

SENGER, F. L., BOTTON, J. J., and MURRAY, G. E. Bilateral hypernephroma. *J. Urol.*, Jan., 1947, 57, 106-115.

The authors were able to find 16 authentic cases of primary bilateral hypernephroma in the literature. They report the case of a twenty-seven year old woman who had hematuria in 1933 with a completely negative urologic workup. Eight years later she was seen again complaining of weight loss and a painless swelling in the left upper quadrant. A bilateral pyelogram showed a normal right kidney and a distorted left kidney, typical of renal neoplasm. A nephrectomy was performed and a histopathological diagnosis of hypernephroma made on the specimen removed.

The patient was asymptomatic for eighteen months and then there was recurrence of painless hematuria. A retrograde pyelogram at this time showed elongation of the lower calices of the remaining right kidney typical of tumor. The kidney was explored with the idea of a possible resection or implantation of radon seeds. A biopsy specimen showed hypernephroma. Deep external irradiation was given postoperatively but this did not prevent continued growth of the tumor.

A peculiar finding was metastasis of the tumor to the thyroid gland.

The authors present their arguments favoring the occurrence of two primary malignancies in this case rather than one kidney lesion being metastatic from the other.—*Rolfe M. Harvey.*

Doss, A. K. The management of uretero-pelvic juncture obstruction; translumbar aortography an adjunct. *J. Urol.*, March, 1947, 57, 521-541.

Ureteropelvic junction obstruction is usually due to some congenital anomaly such as aberrant vessels, "fibrotic bands," high ureteral

insertion, or malrotation of the kidney. The onset of subsequent hydronephrosis is usually insidious and asymptomatic until kidney destruction is advanced. The obstruction may appear unilateral but is usually potentially or actually bilateral. If a unilateral nephrectomy is performed under the impression that only unilateral obstruction exists, compensatory hypertrophy of the remaining kidney may convert a potential into an actual obstruction.

The symptom of ureteropelvic junction obstruction may be that of long continued intermittent chills and fever, renal tenderness, palpable mass and pyuria or hematuria. The symptoms may suggest gastrointestinal disease.

The excretory urogram is a valuable diagnostic aid in the problem of ureteropelvic junction obstruction. Poor visualization does not necessarily mean poor function but may be due to dilution of the medium by retained urine. Films made one to two hours after injection of the medium should be routinely employed. The author advises delaying retrograde studies until just prior to surgery and then only if continuous ureteral catheter drainage is to be maintained until surgery. This is because the author fears introduction of infection into a rich potential medium.

If the excretory urogram shows minimal obstruction the author recommends filling the renal pelvis with opaque medium and making a delayed film ten to fifteen minutes later, the patient having been allowed to assume the erect position in the interval.

The author bases his decision in regard to nephrectomy versus plastic surgery on the condition of the arterial tree of each kidney as determined by aortography. This is also of value in the diagnosis of aberrant vessels as the cause of the obstruction, except where the lumen of the vessel is not patent. The technique of pyeloplasty is discussed and several case abstracts with illustrative films presented.—*Rolf M. Harvey.*

JEWITT, HUGH J. Infiltrating carcinoma of the bladder. *J.A.M.A.*, June 7, 1947, 134, 496-500.

An inquiry into the reasons for the existing low survival rate in cases of infiltrating carcinoma of the bladder has disclosed four cardinal causes of failure with any method of treatment: (1) pre-existing metastases; (2) pre-existing extravesical extension; (3) intercurrent complications, and (4) incomplete destruction

or extirpation of the primary growth. It therefore seems obvious that accurate evaluation of the efficacy of any treatment in the total eradication or primary infiltrating tumors will depend first on the exclusion of metastasis and extravesical extension. Two general causes exist for low curability: (1) late diagnosis, at which time there is usually extravesical spread, and (2) inefficacy of treatment, which allows a tumor without extravesical spread to persist, often unrecognized, in the bladder wall until it has extended extravesically or metastasized.

In a series of 107 cases of infiltrating carcinoma of the bladder on which autopsies were performed, the cases were separated into three groups; Group A—penetration limited to the submucosa. Group B—infiltration had extended into, but not through the muscularis. It therefore seems justifiable to segregate bladder tumors according to the three major categories, papillary, epidermoid and undifferentiated carcinoma, and in the papillary and epidermoid groups to record the poorly differentiated varieties. A section, however, which shows only a well differentiated carcinoma may be misleading, for in another area of the same tumor the cells may be totally undifferentiated.

The diagnosis will be made earlier when the patient and his physician fully appreciate the disastrous consequences of apathy toward slight hematuria or vesical irritability, especially in patients over forty years of age. The diagnosis is necessarily incomplete unless three specific procedures are carried out. These are cystoscopy, biopsy and bimanual palpation under suitably relaxing anesthesia. Extravesical extension, with or without fixation, is readily recognized and indicates the presence of metastasis in the great majority of poorly differentiated tumors and in nearly all undifferentiated tumors. Rubbery induration without extravesical extension denotes a slightly lower incidence of metastasis. No palpable induration, with the patient under completely satisfactory anesthesia and relaxation, indicates in practically all cases absence of metastasis and therefore a high potential curability. Roentgenograms of the chest, spine and pelvis, excretory urography and the examination at laparotomy of the bladder, regional lymph nodes and liver complete the appraisal of the gross pathologic condition.

In cases without metastasis and extravesical extension a good prognosis presupposes com-

plete eradication of the tumor of the bladder and early, adequate treatment of future recurrences.—*Samuel G. Henderson.*

PRIESTLEY, JAMES T. The surgical treatment of carcinoma of the bladder. *J.A.M.A.*, June 7, 1947, 134, 507-513.

Author's Summary. Many factors must be considered in deciding on the most desirable type of treatment for a patient who has carcinoma of the bladder. These include the size, grade and location of the lesion, the degree of infiltration, whether the lesion is single or multiple, whether the ureterovesical orifice is involved on one or both sides, the status of renal function, the age and general condition of the patient and the risk and prospect of cure afforded by various available procedures. It should be remembered that even the most capable cystoscopist is subject to the inherent limitations of all transurethral procedures in treating a vesical carcinoma through the cystoscope. It is thought that in general the treatment of vesical neoplasm has been too conservative in type. External irradiation is not considered a primary treatment of choice.

The principal suprapubic procedures employed in the eradication of vesical neoplasm are electroexcision and fulguration, with or without the simultaneous implantation of radon, segmental resection (in rare cases local excision) and total cystectomy. Segmental resection seems satisfactory for a limited number of properly situated growths. Total cystectomy is in the process of being re-evaluated and it is thought that its field of usefulness is broader than has been appreciated in the past. Bilateral ureterosigmoidostomy, which can be performed in most cases of vesical neoplasm, is considered the desirable form of diversion of the urinary flow in association with total cystectomy.—*Samuel G. Henderson.*

CRABTREE, E. G. Venous invasion due to urethrograms made with lipiodol. *J. Urol.*, Feb., 1947, 57, 380-389.

Venous invasion due to media used in urethrography may occur as the result of undue pressure of the injecting syringe or from the resistance of the bladder and abdominal walls in voiding against urethral obstruction. Twenty-seven cases have been reported in the literature in 2 of which infection of the anterior urethra was present and would account for the invasion

by rendering the urethral mucosa more permeable. Four deaths occurred from oil emboli in the 27 cases. In 2 cases urethral strictures were forcibly dilated by liquid petrolatum. One death resulted from iodipin soon after injection. Fat emboli were demonstrated in 2 of the 3 cases. There were no deaths from lipiodol.

The author gives an illustrative case report. He concludes by warning that urethrography should not be employed in the presence of acute urethritis, after injury, after instrumentation of the urethra and that no undue force should be employed during the procedure. Thorium should not be used as a medium.—*Rolfe M. Harvey.*

LONDON, M. Z. Bilateral calcified testicular gumma. *J. Urol.*, March, 1947, 57, 564-566.

Tertiary syphilis of the testicle was reported 14 times in a series of 12,500 urological patients. Two types of lesions occur: gummas, and diffuse fibrosis.

Gummas are usually single with a central necrotic area surrounded by a fibrotic zone. Histologically these show round cell infiltration and fibrous tissue replacement of the tubular structure.

In diffuse fibrosis of the testicle the entire testicle is involved. This may represent a late stage of gumma.

The author reports the case of a thirty-three year old Negro who complained of hardening of the testicles and decreased sexual power of six months' duration. A diagnosis of luetic orchitis had been made at the onset of the disease which was characterized by fever, malaise, and painful swelling of the testicles. Following intravenous mapharsen the pain and swelling of the testes subsided and the latter became stony hard. Clinically both testicles felt stony hard. Roentgen examination showed both testicles to be heavily calcified. One testicle was removed and a histopathological diagnosis made of fibrosis and calcification compatible with gumma. No treponema were found.—*Rolfe M. Harvey.*

SKELETAL SYSTEM

LANDOFF, G. A. Über Osteomyelosklerose. (Osteomyelosclerosis). *Acta radiol.*, 1944, 25, 81-94.

Osteomyelosclerosis is a rare disease about which little is known. Only about 20 cases are